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Case studies on the curriculum and pedagogy in chemistry and science education in Syria today

By

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Summary

This dissertation analyzed aspects of the nature of science teaching in Syria with a special view on chemistry education. It contains three inter-related case studies on the intended curriculum as well as teachers' and students' views on the operated curriculum. The intended science curriculum in Syria has been inquired based on a case study analyzing the official grade-10 chemistry school textbook in comparison to six other chemistry textbooks from a purposeful sample of Arab countries, namely Algeria, Egypt, Kuwait, Palestine, Jordan and Saudi-Arabia.. The second part of this thesis analyzed teachers' views on chemistry and physics teaching based on interviews. Issues of the interviews were the use of ICT, laboratory work, including the history of science in teaching, and the teachers' view on the national curriculum. In a third approach, grade-10 science students' experiences, attitudes and views towards science education were surveyed by interviews with respect to their possibilities for participation in the science classroom, practical work, out-of-school science education, and their current views on potential careers in science and technology. The findings suggest that although the Syrian ministry has installed an independent sector for curriculum development the level of the current school science education still needs rigorous reform when compared to international standards. This claim became evident in all the three case studies conducted in this thesis.

The intended curriculum as represented in the official school textbooks – analyzed here in the case of the grade-10 chemistry textbook - shows indications of modernizing science education in Syria. The new Syrian chemistry textbooks is more modern than older ones in terms of contextualization, suggestion for students' active learning, connecting science to society and everyday life. It proved to be more student-oriented than textbooks from Palestine, Kuwait and Algeria where chemistry textbooks tend to focus on purely theoretical concepts rather than contexts, activities or connections to life and society. However it still less modern than textbooks from other Arab countries, e.g., Egypt and Saudi Arabia. It is thus evident that even though some effort has been made to improve the quality of the intended curriculum this effort needs to be continued to influence science education in Syria to meet international developments and standards.

From the point of view of teachers as well as students, the Syrian science curriculum is still quite bulky and complex, despite its minor improvements in the new textbooks. The inclusion of various activities illustrations intend to make science learning much more engaging to the students, but the questions remains to which degree this is operated. The case studies on teachers' and students' views on the operated curriculum in science education showed that science education in Syria is lacking student-centeredness and constructivist approaches to science teaching. It shows that teachers' intentions and practices hardly meet students' expectations. This is even more the case in the public than in the private schooling sector. Both an orientation on students' interests and a student-active pedagogy is missing in most cases. These practices are strengthened in times of the Syrian civil war that led to problems in infrastructure, information access and problem caused by migration and displacements.

The findings and inter-relation of the three case studies suggest that there is a thorough need for continuing reform accompanied by groundbreaking implementation efforts as well as investment in teacher education and continuous professional development.

Zusammenfassung

Diese Dissertation analysiert verschiedene Aspekte des naturwissenschaftlichen Unterrichts in Syrien mit einem besonderen Fokus auf die schulische Bildung im Bereich Chemie. Die Dissertation enthält drei sich gegenseitig ergänzende Fallstudien zu den curricularen Rahmenbedingungen, sowie zur Sicht der Schüler und Lehrer auf diese Bedingungen und die Situation im naturwissenschaftlichen Unterricht im Allgemeinen. Der momentane Lehrplan in den naturwissenschaftlichen Fächern in Syrien wird basierend auf einer Untersuchung analysiert, welche die offiziellen Chemiebücher von der zehnten Klasse mit sechs anderen Chemiebüchern aus einer Stichprobe anderer arabischer Länder wie Algerien, Ägypten, Kuwait, Palästina, Jordanien und Saudi-Arabien vergleicht. Der zweite Teil analysiert die Sicht der Lehrer auf das Unterrichten von Physik und Chemie. Die Analyse basiert auf semi-strukturierten Interviews mit Schwerpunktlegung auf die Verwendung von ICT, Laborarbeit, historische Aspekte im Unterricht sowie die Einschätzung des nationalen Lehrplans aus Lehrersicht. Die dritte Fallstudie bezog sich auf Erfahrungen von Schülern der zehnten Klasse im naturwissenschaftlichen Unterricht, sowie ihre Einstellung gegenüber ihrer naturwissenschaftlichen Ausbildung. Dies wurde ebenfalls mit Hilfe von Interviews untersucht, und zwar in Hinsicht auf ihre generellen Möglichkeiten, am naturwissenschaftlichen Unterricht teilzunehmen sowie auf die Möglichkeiten, im Unterricht praktisch zu arbeiten. Darüber hinaus lag ein Fokus auf der außerschulischen Bildung im Bereich der Naturwissenschaften. Außerdem wurde die momentane Sicht der Schüler auf eine potentielle Karriere im Bereich Wissenschaft und Technik miteinbezogen. Die Ergebnisse zeigen, dass obwohl das Syrische Bildungsministerium einen unabhängigen Sektor für die Lehrplanentwicklung ins Leben gerufen hat, die naturwissenschaftliche Ausbildung in Schulen immer noch eine grundlegende Reform benötigt, vor allem, wenn man das momentane Leistungsniveau mit dem internationalen Standard vergleicht. Dieses Ergebnis zeigt sich in allen drei Fallstudien dieser Dissertation.

Der derzeitige Lehrplan (repräsentiert durch die offiziellen Schulbücher der 10. Klasse) zeigt Anzeichen von Modernisierungsmaßnahmen in Bezug auf die Gestaltung des naturwissenschaftlichen Unterrichts. Diese Maßnehmen beziehen sich in erster Linie auf die Kontextualisierung. Die neuen Schulbücher enthalten im Vergleich zu den älteren Ausgaben mehr Vorschläge für aktives, schülerzentriertes Lernen sowie Verknüpfungsmöglichkeiten zwischen den Naturwissenschaften, der Gesellschaft und dem alltäglichen Leben. Es erwies sich als in höherem Maße schülerorientiert als die Schulbücher von Palästina, Kuwait und Algerien, welche ihren Fokus auf die theoretischen Konzepte in der Chemie legen. Nichtsdestotrotz entsprechen die syrischen Schulbücher immer noch veralteten Standards, wenn man diese mit anderen arabischen Ländern wie Ägypten und Saudi-Arabien vergleicht. Daher zeigt sich deutlich, dass auch wenn schon Maßnahmen ergriffen worden sind um die Qualität des Lehrplans in Syrien zu verbessern, die Bemühungen fortgesetzt werden müssen, damit die naturwissenschaftliche Bildung in Syrien nationale sowie internationale Standards erfüllt. Aus der Sicht der Lehrer und Schüler ist der syrische Lehrplan noch deutlich zu umfangreich und zu komplex, trotz der geringfügigen Verbesserungen in den neuen Lehrbüchern, welche größtenteils durch den Einsatz von mehr Illustrationen durchgesetzt wurden. Inwieweit diese für die Schüler motivierend sind, kann in Frage gestellt werden. Die Fallstudien über die Ansichten der Schüler und Lehrer in Bezug auf die neuen Lehrpläne der naturwissenschaftlichen Fächer zeigen, dass die Ausbildung in den naturwissenschaftlichen Fächern in Syrien nicht die Interessen der Schüler wiederspiegelt, sowie konstruktive Ansätze bezüglich des Unterrichtens fehlen. Des Weiteren

konnte gezeigt werden, dass sich die Intentionen bzw. Ansprüche der Lehrer und die Erwartungen der Schüler widersprechen. Dies ist in öffentlichen Schulen ausgeprägter als im privaten Schulwesen. Die Ausrichtung auf die Interessen der Schüler sowie eine aktive an die Schüler gerichtete Pädagogik fehlen in den meisten Fällen. Diese Probleme werden verstärkt durch den syrischen Bürgerkrieg, der zu Problemen in der Infrastruktur sowie bei dem Zugang zu Informationen führt.

Die Ergebnisse der drei Fallstudien zeigen, dass es einen starken Bedarf für die Fortsetzung der Reformen gibt. Um diese erfolgreich fortzusetzen, bedarf es weiterhin starker Bemühungen im Bereich der Weiterbildung der Lehrkräfte und einer Weiterentwicklung im Qualitätsmanagement.

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Chapter 1: General introduction

Introduction

Up until the beginning of the civil war in Syria in 2011, young people in Syria were considered to be among the most educated students in the Middle East region (Al Hessan, 2016). During the many years of war, many students of this young generation became refugees and left Syria or were displaced within Syria. Especially in 2015, large numbers of refugees from Syria made their way across Turkey and the Mediterranean Sea towards Europe to apply for asylum, e.g., in Germany, Austria, or Sweden. The Syrian crisis put Syria into focus internationally, both in terms of the civil war itself, and with saving and dealing with the large numbers of refugees. This also raises important questions for the international community in terms of education. To cope with the situation of Syria in wartime and also the challenge to educate refugees of a young age in foreign countries ask for a better understanding of the educational system in Syria before the civil war and how the war affected the educational sector as an important part of the developments in Syria and among the Syrian refugees – today and for the future.

The Syrian Republic is currently faced with big challenges. This also concerns the educational system with a decreasing access to academic and financial resources, a loss in human capital, and strong damages in infrastructure (El Hillo, 2016). The continuing decline in resources impacts any efforts in scientific endeavor, as well as in basic to academic education. The situation in Syria in terms of higher education has been described as producing substandard scientific research.The absence of critical assessment for higher education and schools seems to lead to restrictions in global outreach, unavailability of publications in English language, and an unmotivated faculty and teachers as has been described in previous studied cases in the Arab world (Almansour, 2016). However, there are still some schools that try to offer high quality education in Syria with the aim to educate internationally competitive students through reformed curricula and pedagogies. But, also these institutions cannot avoid being impacted by a country under war. However, even during the time before the civil war it was identified that there was a need for educational reform in Syria in general, and in science education in particular.

In the past decades, many Arab countries have acknowledged the necessity of educational reforms to counter the falling standards of education and have put it on their agenda (Dagher & BouJaoude, 2011; Al-Amoush, Markic, Eilks & Abu-Hola, 2011). The aim was to build an educational infrastructure that is compatible and competitive with twenty-first century standards in developed countries. The aim was – and still is - to educate strong and well-qualified members of the present day global world societies. However, improvements in the educational system are only possible if the ministries of education in these countries build reform on evidence, overcome the purely top-down approaches of the past, decentralize their power and abstain from authoritarian reform systems, systems that hinder the professional growth of academics and school teachers and prevent open minds among the practitioners by bureaucracy and paternalism (Faour, 2011).

In order for a country to ensure a strong and efficient educational system, it is highly necessary that sufficient financial investment is made in it and that infrastructure and access to information are stable. A strong economy can get the ball rolling and contribute towards attaining a highly effective and efficient educational system which in turn provides positive returns to society as more education leads to higher productivity and wages (Angrist & Krueger, 1991; Ashenfelter & Krueger, 1994; Card, 1995). Some of the Near and Middle East countries – among them Syria – are generally rich because they are exporters of petroleum with sixty percent of the Earth's petroleum reserves located in Arab countries. However, several of these countries until today have struggled to achieve a stable economy resulting in educational quality. The consequences resulted in youth unemployment with an estimate of twenty to thirty percent of the Arab young population (age 15 to 29 years old) having no jobs (Constant, & Kraetsch, 2010). According to the United Nations Development Program (2003), even those Arab countries with a stable economy and ample financial resources struggle with their educational achievements. Investments in educational reforms in recent years in these countries have been basically focused on building ICT infrastructure (UNESCO, 2013) while many other important factors that construct a better educational system, like reformed and updated curricula, teachers' continuous professional development, and growth of students as individuals, have been neglected.

Technology has become a central part of our lives that facilitates communication, work, trade, and leisure all over the world with the accessibility of radio, the television and the personal computer and, later, the internet, creating a revolution especially in communication and education (Nachmias, 2003). Consequently, the focal point of educational reforms in the Arab countries was set on the internet, modern technologies and multimedia (Masri & Wilkens, 2011). Social media started to be used on mobile phones and other special devices, especially when people request information but also to help to raise awareness of democracy, human rights, and civil freedom (Saacs, 2012). Computer technology is becoming more and more common with the progress of technology development. However, the question must be asked as to whether new technology should be used purely due to its availability or because it reconciles with modern educational goals (Srinivasan & Crooks, 2005). The question is also whether information and communication technology is really utilized in teaching and how, and, if it is, how does it contribute to improving students' learning. For instance, the educational system in developed countries is very strong due to the governmental financial support (Anderson, 2011). Nevertheless, some researchers claim that there is no direct correlation between financial support and students' outcome within any educational system (Hanushek, 1986). This is also supported by the PISA studies, where no direct relationship between the level of economic development and general achievement can be traced. However, even in PISA one can see that the chances to perform better are rising with overall economic development, if high-income economies tend to focus on the quality of teachers over the size of classes and if the school systems believe that all students can achieve high results, and give them the opportunity to do so (OECD, 2012).

From theory it can be said that teachers should be well-prepared and acquainted with the latest teaching methodologies (EL-Baz, 2009). A teaching career must be chosen by the teachers willingly as early as possible through university stage, with a belief that this kind of training will enable them to bring about positive, prolific changes in the youth contrary to the commonly held attitude of teachers prioritizing themselves as being scientists over being teachers that impart knowledge (Al-Amoush, Markic & Eilks, 2012). However, the emphasis and view of the teachers on their teaching is not only impacted by their education. This view is also influenced by the guidance and directives teachers receive from educational authorities, such as the ministry of education. The image teachers have of themselves and their subject is also influenced by the intended curriculum given by the ministry of education and represented by the official textbooks. Textbooks are ambassadors of the subject and the intended curriculum to both the teachers and students (Devetak & Vogrinc, 2013). The Syrian science curriculum, as presented by its textbooks, has witnessed an obvious evolution in the last six years as the Syrian Ministry of Education formed a committee to develop the Syrian science curriculum. The old curriculum depended on a purely teacher- and contentment-centered style that marginalized the role of students and limited their activity to rote learning (Muhanna, 2011).It had a great tendency toward delivering pure knowledge and focusing on raw content while ignoring any attempt to improve students' skills. In the new curriculum, the intention to release students from restrictions and to give them more space to be creative and independent to focus on self-learning is expressed (Muhanna, 2011). These changes in the curriculum and the textbooks require training workshops for teachers in order to understand the new mechanisms of teaching.

In Arab countries, reforms and curricula are mainly implemented top-down with low influence of the teachers (Dagher et al., 2011). Although research and educational theory suggest that successful curriculum development and implementation should involve teachers and take into consideration their prior knowledge and opinions about the curriculum or school textbooks before its publication (Olson, 1976), this is hardly the case for many Arab countries (Dagher et al., 2011, Al-Amoush et al., 2012). Research suggests that teachers should play a central role in curriculum development and textbook implementation thus continuous professional development (CPD) is needed to form a platform that connects teachers, educators, and curriculum developers. Such platforms allow them to collaborate and work together to improve the standards of education. CPD also facilitates teachers in adopting the most promising and current pedagogies of teaching.

The core of structuring effective CPD for teachers is to be aware of their prior knowledge, beliefs and views (Anderson & Helms, 2001; Van Driel, Beijard & Verloop, 2001). The knowledge, beliefs and views should be taken into consideration for interactive and long-term CPD, e.g. based on action research innovations (Mamlok-Naaman & Eilks, 2011). Such an approach will enable teachers to develop their skills in teaching so that learning in classrooms becomes more challenging and interesting. Teachers and curriculum reformers should also take the views and interests of students into account for building up self-confident learners who are becoming able to cope with their personal and professional lives in their future. However, there is not very much known about teachers' prior knowledge, beliefs and views in the teaching and learning of the physical sciences in the Arab world in general, and in particular there is nearly no evidence for the case of Syria. The same holds true for knowledge about how students perceive their science lessons in Syria.

This thesis surveys education in the field of physical sciences in Syria based on educational case studies encompassing three main foci, namely the curriculum, the teachers, and the students. For the curriculum, the intended 10^{th} grade chemistry curriculum, as it is represented by the official acknowledged and nation-wide used textbook, is analyzed and compared to intended curricula in a purposeful selection of six other Arab countries, namely Algeria, Egypt, Jordan, Kuwait, Palestine, and Saudi-Arabia. In the analysis, several issues of visual and verbal representations of the curriculum are analyzed leading to identifying the curriculum orientation and curriculum emphasis of the intended chemistry curriculum in Syria between modernity and traditionalism, and in relation to the intended curricula from other Arabic countries (Khaddoor, Al-Amosuh & Eilks, 2017).

The second topic focuses on teachers' beliefs and views on several issues of teaching and learning the physical sciences. Issues taken into focus are teaching and learning based on information and communication technology, practical work, operating the history of science, and the teachers' views towards the intended curriculum. The case study operates a sample of teachers with varying levels of age, gender, years of experience, and their work in public or private working environments. The goal of the study is to identify if there are any beliefs towards modern issues of teaching science and student-centeredness, maybe even related to certain aspects of the teachers' personal characteristics. The study will reflect on whether the teachers are in line with the intended reforms towards more contextualized and student-centered teaching methods, whether they are open to it, and whether any aspects of the reform are on the way to being implemented – even in the times of the civil war.

Finally, the third part of this study tackles students' attitudes towards science learning and their perception of the science classroom environments they generally experience, including their views on out-of-school learning and professional careers for the future. The study takes a typical description of the science classroom learning environment into focus by asking the students about the interaction between teachers and students, students' activities, any type of students-student-interaction, the role of textbooks, problems the students face, and how they manage to overcome them. The study also surveys to which extent students are interested in science, students' most favoured topics, their views on science as a part of daily life, the type of activities that are practiced outside school to reinforce scientific knowledge, parents' attitudes towards their children's achievement in science, and what their view is about potential careers in science and engineering.

The final part of the thesis will discuss relationships between the findings from all three case studies.

Chapter 2: A comparative analysis of the intended curriculum and its presentation in 10th grade chemistry textbooks from seven Arabic countries

A comparative analysis of the intended curriculum and its presentation in 10th grade chemistry textbooks from seven Arabic countries

This study investigates the nature of intended secondary chemistry curricula, as they are represented by chemistry textbooks, from seven Arabic countries: Algeria, Egypt, Jordan, Kuwait, Palestine, Saudi Arabia and Syria. The curricula are evaluated through analysis of the officially approved 10th grade chemistry textbooks used nationwide in all of these countries. The textbooks were analysed by qualitative content analysis in three cycles. The cycles focused on technical characteristics, the representation of the content, and an overall rating of the intended curriculum based on the findings from the first two rounds in connection to the ideas of the curriculum emphasis and curriculum orientation. The overall rating focuses on the orientation of the intended curricula, the emphases behind them, and indicators of any student-centred pedagogy. Our findings show that the textbooks differ widely. Some textbooks from this sample proved to be very traditional and purely organized in terms of the chemistry content with very limited connections of the content to modern aspects or applications of chemistry. The curricula in Algeria, Kuwait and Palestine were found to be of this kind. The textbooks from these countries basically operate a fundamental chemistry and structure-of-the-discipline approach. Other textbooks actually represent more modern approaches in chemistry teaching by providing a recognizable degree of contextualisation or even societal orientation. This is the case for Egypt, Syria and Saudi Arabia and, to a lesser degree, for Jordan. In the case of Palestine, the textbook focuses almost exclusively on content in technical and engineering contexts. Our analysis shows that there is no clear relationship between the intended chemistry curricula and certain characteristics in the corresponding countries, namely the regional background, the level of economic strength, and the degree of traditionalism.

Introduction

In many countries of the world, e.g. Western countries, traditional secondary science and chemistry curricula in the 1960s and 1970s have been previously described as following the primary goal of giving a limited portion of students a solid foundation in science in order to recruit them for future careers in science and engineering (Bybee and DeBoer, 1993; van den Akker, 1998; Eilks et al., 2013). The resulting secondary chemistry curricula focused mainly on the learning of pure chemistry facts and theories. Corresponding school chemistry textbooks were structured parallel to general chemistry books used at the university level. Ever since the 1980s, however, new goals and standards for secondary chemistry education have emerged in many countries of the Western hemisphere or, e.g., in China (Wei and Thomas, 2005). The focus has shifted towards providing every future citizen with a basic understanding of chemistry, so that people can better cope with life, both individually and as a society. The curricula proposed for secondary chemistry education accordingly changed. They suggested that chemistry should be taught from everyday life perspectives, or in environmental or societal contexts (Eilks et al., 2013). However, the depth of implementation of such an approach is still insufficiently developed in many cases (Hofstein et al., 2011). Also for the Arabic countries it was suggested that ways should be sought to better engage the younger generation in scientific and engineering studies (Abd-El-Khalik et al., 2015). The shift in school chemistry and science curricula since the 1980s is supported by a whole set of educational theories. Activity Theory as discussed by Holbrook and Rannikmae (2007) and Allgemeinbildung as recently reflected upon by Sjöström and Eilks (2017) are two examples. These theories suggest that current curricula for secondary school chemistry education need to not only emphasize the learning of scientific theories and knowledge, but must also support the development of science-related and general educational skills. Additionally, the theory of situated cognition (Greeno, 1998) suggests that effective chemistry learning needs to be contextualized, if the goal is to develop skills in learners, who are supposed to apply the knowledge gained. Meaningful contexts need to be used in order to introduce necessary chemistry knowledge and to promote the corresponding skills (Gilbert, 2006). Chemistry education needs to focus on better understanding the science related questions taken from everyday life, relating to future career choices, and for decisions which pupils currently have to make about personal and societal issues (Hofstein et al., 2011; Eilks et al., 2013). They also should understand science as a way of thinking and seeing the world (Mansour, 2010). Such a view was also proposed by Stuckey et al. (2013) with the help of an organizer for reflecting the relevance of science education. This theory suggests that there are three different dimensions of relevance in science education: individual, societal and vocational. The preparation of future scientists is immanent in all three dimensions but constitutes only a small part of them. All the above-mentioned points-of-view should be taken into consideration when structuring the secondary chemistry curriculum as represented (at least in the intended form) by the corresponding chemistry school textbook in use in a given country (Devetak and Vogrinc, 2013). This study focuses on the extent to which these viewpoints are expressed in current chemistry textbooks taken from a sample of Arabic countries. Our study examines the nature of the intended secondary chemistry curriculum in Arabic countries. The seven selected nations represent a spread from a large region with more than 300 million inhabitants, who identify themselves through a lot of commonalities in culture, language and religious beliefs (Dagher and Boujaoude, 2011). Seven school textbooks were selected, one each from Algeria, Egypt, Jordan, Kuwait, Palestine, Saudi

Arabia and Syria. This selection is suggested to represent the whole of the entire Arabic world from North Africa to the Near East and the Gulf countries. It also includes countries with higher and lower levels of economic strength, as well as countries with more traditional as compared to more secular societies. The intended chemistry curricula examined here are analysed with the help of the official, government-approved 10th grade chemistry textbooks used nationwide in all seven Arabic countries studied. The analysis concentrates on the orientation of the curriculum (De Jong, 2006), the existence of any indicators of student-centred pedagogy (Devetak and Vogrinc, 2013), and curriculum emphasis as introduced by Roberts (1982) in an interpretation for chemistry curricula found in the study by Van Berkel (2005). The analysis identifies whether current chemistry textbooks from the seven Arabic states are in line with modern theories of chemistry curricula. It also attempts to localize any relationships of the nature of the chemistry curriculum with regional, cultural or socioeconomic differences among the seven countries.

Theoretical framework

Curriculum emphases and orientations of chemistry curricula as a basis for the analysis of intended chemistry curricula as represented by textbooks

Roughly thirty years ago Roberts (1982) reviewed science curricula from North America covering almost one hundred years of science education. He suggested that every curriculum contains a set of hidden messages about the nature of science. He dubbed this set of messages the curriculum emphasis and described it as ‘ ‘. . . a coherent set of messages about science (rather than within science). Such messages constitute objectives which go beyond learning the facts, principles, laws and theories of the subject matter itself ‑ objectives which provide answers to the student question: Why am I learning this? (Roberts, 1982, p. 245).

Roberts originally identified seven different curriculum emphases. However, he also stated that these different emphases are not sharply divided from each other, that they might change over time, and that they are often combined to create completely new meanings. This was recently seen in the work of Van Berkel (2005). Van Berkel tried to update the idea of the curriculum emphases with respect to more recent curricula within the domain of chemistry education. He refined the original seven emphases and combined them into three more general ones. He called these three areas: Fundamental Chemistry (FC), Knowledge Development in Chemistry (KDC), and Chemistry, Technology and Society (CTS). Table 1 gives an overview of Van Berkel’s curriculum emphases as given in Van Driel et al. (2007). With reference to the analysis of science textbooks, Mansour (2010) used a similar differentiation. However, this work did not make reference to the curriculum emphases concept of either Roberts (1982) or van Berkel (2005) as it reflected upon the nature of scientific literacy in science curricula.

Table 1. Curriculum emphases in chemistry education by Van Berkel (2005) adapted from Van Driel, Bulte and Verloop (2007)

Fundamental Chemistry (FC)	Fundamental Chemistry emphasizes the preferential learning of theoretical concepts and facts. Behind this curriculum stands the philosophy that concepts and facts need to be taught first. It is believed that they will provide the best basis for understanding phenomena from the natural world and provide the best starting point for students' further education later on.
Knowledge Development in Chemistry (KDC)	A central orientation on Knowledge Development in Chemistry is connected to the idea that students should learn both how and in which socio-historical context chemistry knowledge is and was developed. Students should learn to see chemistry as a culturally-determined system, in which knowledge is constantly developing.
Chemistry, Technology, and Society (CTS)	Chemistry, Technology and Society focuses explicitly on the relationship between science and technology and the role of science within societal issues. It is believed that students should learn to communicate and make decisions about societal issues that are connected to aspects of chemistry and technology.

In 2006, De Jong suggested four different domains that can be utilized to offer learners approaches to learning chemistry: the personal domain, the professional practice domain, the professional-technological domain, and the social and society domain. The latter domain aims to prepare students to become responsible citizens in the future. De Jong's domains largely overlap with the dimensions of relevant chemistry education. These were called the individual, societal and vocational dimension by Stuckey et al. (2013). By using De Jong's four focal points, Eilks et al. (2013) recently suggested the idea of general orientation of the chemistry curriculum. These general orientations offer textual approaches from which to start individual lessons, but the orientations can also be used as guiding principles for structuring the whole curriculum:

- Structure of the discipline orientation: the inner structure of academic chemistry is used as an organizer of the chemistry curriculum. These curricula mainly focus on the learning of scientific theories and facts and their relation to one another. The resulting curriculum looks like a 'lighter' version of a university textbook on general chemistry.
- History of chemistry orientation: the history of chemistry is used to structure the curriculum. Content should be learned as it emerged in the past, but also allow learning about the nature of chemistry and its historical development. Lesson plans are often planned using actual episodes from the history of chemistry, which refer to the life of real chemists.

- Everyday life orientation: everyday life issues are used to aid entry into the learning of chemistry. Learning should become meaningful for the student. For example, the use of household cleaners is used as a context for approaching acid–base-chemistry.
- Environmental orientation: environmental issues are used to provoke learning of the chemistry behind an issue, including questions of environmental protection. Examples include water treatment, air pollution, and acidic rain.
- Technology and industry orientation: developments from technology and the chemical industry are selected in order to learn about chemistry and its applications. Teaching in a more in-depth application also focuses on the interplay of science and technology within society. For example, crude oil distillation and the industrial production of important metals are used as techno-industrial issues for chemistry lesson plans.

Socio-scientific issues orientation: socio-scientific issues form the starting point of chemistry learning. This allows students to develop general educational skills to prepare them to be responsible citizens in the future. Examples include the debate about climate change or the effects on the use of biofuels for the economy, ecology and society.

Generally, all of the domains suggested by De Jong (2006) and orientations outlined by Eilks et al. (2013) can be used to create both starting points and guidance for structuring chemistry lessons. All of them can be understood as a context of one type or another (Gilbert, 2006). However, contexts which mean something to the student in the sense of the theory of situated cognition (Greeno, 1998) must be connected to students' interests and prior experiences. This is commonly not the case for both the structure of the discipline and history of chemistry approaches. Everyday life and environmental contexts might be closer to secondary school students' lives, since most children in this age group tend to be non-intrinsically science-oriented. But technological and societal issues may offer easier links to contextualize chemistry learning (Eilks et al., 2013), since these issues are more likely to be directly perceived as meaningful and relevant. This idea has also been supported by findings which analyzed and compared representations in historical chemistry textbooks. Such studies have suggested that more numerous and lively illustrations in textbooks are better in terms of raising positive learning attitudes and learner achievement (Milanovic et al., 2015).

In terms of the curriculum emphases suggested by van Berkel (2005), the structure of the discipline approach is quite closely related to Fundamental Chemistry. A historical orientation can support an emphasis on Knowledge Development in Chemistry. A technology and industrial focus may also do the same, if it is explicitly connected to certain technological developments in the past. The Chemistry, Technology and Society approach demands content and contexts which incorporate issues from both the students' individual lives and from society at large. Understanding the interplay between chemistry, everyday life, the environment, and technology is necessary for pupils to understand and take part in the wider socio-scientific issues related to chemistry (Eilks et al., 2013). This aids learners in the development of corresponding and crucial decision-making skills.

Textbooks as representations of the intended curriculum and pedagogy

To understand which curriculum emphasis dominates a particular educational environment and domain, the textbooks in use can serve as a reference point. Devetak and Vogrinc (2013) suggest that textbooks link any school subject with the students. Much like ambassadors, textbooks represent the subject to the pupils (Devetak and Vogrinc, 2013). They suggest the ideal and formal curriculum (Van Den Akker, 1998) which the teacher is expected to carry out on behalf of the school system and thus how chemistry is presented to the learner.

In many countries textbooks provide variability, which is partly affected by a textbook authors' personal style. They also transmit their own viewpoints into national curricula. However, if there is only one textbook officially approved by educational authorities, they also represent a de facto curriculum emphasis which has been selected by the corresponding ministry of education (Martı´nez-Gracia et al., 2006). Textbooks may also represent commonly used teaching practices underlying the curriculum, since they are commonly written by educators and experienced teachers within the system. Many teachers explicitly depend on the textbook to guide their teaching efforts (Stern and Roseman, 2004). This can also have consequences, for example whether an FC curriculum is dominant in the textbook, which would represent chemistry to the students mainly as an intellectual and academic challenge. Placing a CTS emphasis in the foreground would have the effect of stressing the importance of the application of chemistry in everyday life, environment and society.

Devetak and Vogrinc (2013) also suggested that textbooks indicate classroom practices. Two questions the authors raise are the use of visualization and the level of language quality. They believe that more richly illustrated textbooks represent a more student-oriented teaching approach. They also state that modern textbooks make broad use of images such as photographs, data-tables, charts, drawings, graphs, and diagrams (Cook, 2008). This means that if textbooks are incomprehensible to or non-qualifiable for students, these texts can actually lead to negative imprints on students and a negative perception of the corresponding school subject. This directly affects student beliefs about how relevant the content to be learned actually is (Irez, 2009).

Chemistry textbooks in Arabic countries

Not very much is known about current chemistry textbooks in Arabic countries in the literature. A general overview of science textbooks was compiled by Dagher and BouJaoude (2011). However, this review mainly discusses cases from general science and biology textbooks. However, part of the findings may parallel the situation also in chemistry education.

One existing comparative study of eleven Arabic science textbooks in the 1990s suggested that the textbooks of that time focused almost exclusively on factual content knowledge. There was very limited focus on either the explicit process of performing science or on developing higher-order cognitive skills such as problem-solving. These textbooks largely ignored the application of science to daily life situations (Nashwan, 1993). At about the same time Badran (1993) described curricula selected from seven Gulf States as behind the times. None of them had apparently benefited from new technologies in teaching science, nor did they exploit science–technology–society interactions in their methods and approaches. Badran also found that the textbooks mainly adopted content taken from international curricula. They neglected local, social and environmental problems, including the application of science on technology and daily life issues. These textbooks also lacked any emphasis on inquiry-based science activities.

A decade later, Arab Human Development (UNDP/RBAS, 2003) and the World Bank (2008) reported similar characteristics in science education in Arabic countries. Their findings were similar to those reported in the studies by Nashwan (1993) and Badran (1993). In 2009, Dagher published a case study examining science education in Egypt, Jordan, Lebanon and Qatar. This study revealed that several dimensions of the nature of science were still absent in corresponding science textbooks. This was particularly the case for the philosophical aspect of science as a pathway to understanding both the methods of science and its historical dimensions. Around the same time, another study by Dagher et al. (2010) looked at four Arabic science textbooks from Jordan, Lebanon, Saudi Arabia and Egypt. It analyzed 9th grade science textbooks and concluded that the nature of science was still a neglected area in science textbooks. Similar results were reported for the Lebanese science curriculum, which also neglects the aspects of the nature of science, while simultaneously making too few connections between science, society and technology (BouJaoude, 2002).

In parallel with the research listed above, one study investigated textbook use in Jordan. It found that both students and teachers viewed textbooks as hard to read, because appropriate levels of comprehensibility and illustration were both missing (Ktait, 2002). Batsh (2006) suggested that most assessment activities used in Arabic textbooks focus almost exclusively on the knowledge domain. Very few look at the nature of science (Al-Ma'aiteah, 2005). The latest Lebanese science textbooks published for the 9th grade level still limit their scope to theoretical facts (Dagher et al., 2010); however, they have started to link science, technology and everyday life somewhat better and increased their efforts in the realm of assessment.

In 2010, Mansour described some textbook improvement in specific cases. In the case of Egypt, he found that the science curriculum now emphasizes both knowledge and the nature of science, which is closely related to the KDC curriculum emphasis. However, he also stated that Egypt still neglects understanding science as a way of thinking. It also neglects the interaction between science, technology and society, which is a key part of the CTS curriculum emphasis. Whether this shift was caused by the teachers is still an unanswered question, just like the effects of many educational reforms in science education in Arabic countries (Dagher and BouJaoude, 2009, 2011).

We cannot say whether all of these findings can be transferred to Arabic chemistry textbooks. Hardly any research information is available, which takes a clear view of the intended chemistry curriculum and any corresponding textbooks. It is also unclear whether any relationships exist between different methodologies for teaching chemistry and any regional, cultural or socio-economic characteristics of the corresponding countries. That is the aim of this study. Our research questions were as follows:

1. *Which curriculum orientations and curriculum emphases are prevalent in 10th grade chemistry textbooks in Algeria, Egypt, Jordan, Kuwait, Palestine, Saudi Arabia and Syria?*
2. *Are there any connections between the orientations or emphases of the chemistry curriculum and the level of socioeconomic development, culture or regional background in the selected countries?*

Sample and methods

Sample

The sample consists of seven 10th grade Arabic chemistry textbooks selected from Algeria, Egypt, Jordan, Kuwait, Palestine, Saudi Arabia, and Syria (Ajloonee et al., 2006; Algneam et al., 2006; Buthelezi et al., 2008; Sadek et al., 2013; Shafea et al., 2013; Shawa et al., 2013; Rimawee et al., 2014). The reason for choosing 10th grade books was that this is the earliest level where chemistry is taught as an (almost) independent subject in all of these countries. It is also the year when most countries begin selective courses in chemistry, so that many students can opt out of chemistry learning. All the textbooks are officially approved by the corresponding political authorities, i.e. the ministries of education. The seven textbooks are the only official grade-10 chemistry textbooks for nationwide use in these countries. Because of the official approval and decision of having only one textbook in use in all public schools in a country the textbooks can be considered to represent the official intended curricula. Appendix 1 of this paper lists some of the characteristics of the seven textbooks. The sample was chosen to represent the largest possible variety of Arabic countries. The range covers everything from extremely rich countries such as Saudi Arabia and Kuwait to less-developed countries like Egypt and Palestine. The Human Development Index covers a wide range of world rankings: place 39 (HDI 0.837) for Saudi Arabia, place 48 (HDI 0,816) for Kuwait, place 108 (HDI 0.690) for Egypt, place 113 (HDI 0.677) for Palestine, and place 134 (HDI 0.594) for Syria. The current study also covers a broad range of different societies, reaching all the way from quite traditional countries such as Saudi Arabia and Kuwait to more secular societies like Egypt and Syria. It also covers geographical locations stretching from the Arab Gulf (Saudi Arabia, Kuwait) to the Near East (Syria, Jordan and Palestine) and northern Africa (Egypt and Algeria).

Methods

The textbook analysis followed a cyclical design. This design followed the basic tenets of qualitative content analysis as suggested by Mayring (2000). Altogether three cycles of analysis were performed. The first cycle focused on the technical characteristics of the textbooks, e.g. the number of pages and the inclusion of experiments or figures. The second cycle attempted to identify the embedding of contextual and pedagogical characteristics. The final round of analysis was used for identification of both the curriculum orientation and the dominating curriculum emphases in each of the books, based on the findings from the first two rounds. The first cycle of analysis followed Devetak and Vorgrinic's (2013) criteria for analyzing textbooks. This cycle focused on the general, overall structures of the books. It included analysis of the number of pages and chapters, the length of the chapters, the percentage of textual and pictorial material in each specific chapter, and of the textbook overall. It also looked at whether or not there was any internal analysis of textual material, elements of text discourse, stimulating observations about phenomena, explicit proposals for practical work, problem-solving exercises, or summaries of important concepts at the end of chapters. This cycle also examined whether realistic images such as photographs were used, whether graphs, diagrams, maps, or molecular structures were included, etc. The first cycle of analysis also identified explicit references to the history of chemistry, direct connections to Islam and Arab culture, specific tasks for Internet searches, usage of non-Arabic words and terms, discussion of safety issues, and references to technical applications of chemistry, if any. The second cycle of analysis identified whether chemistry was embedded in contextual and pedagogical terms. Stress was placed on which contexts had been selected to introduce chemistry content, whether practical work was integrated into the textbook, which (if any) cultural, religious or gender stereotypes had been included, and whether indications could be found that pointed either to more traditional or more modern views of chemistry curricula. Traditional views here are understood as those connected to a structure-of-the-discipline approach to science content, having a low level of applications and everyday life issues, or neglecting modern issues of chemistry, e.g. environmental chemistry, nanotechnology, or modern chemical products. All coding in the first two rounds was performed by two independent native speakers (R. K. and S. A.-A.). The agreement reached in the first two cycles was generally high, ranging at roughly 80%. Points of disagreement were discussed and a joint rating negotiated based on Swanborn's idea of search of intersubjective agreement (Swanborn, 1996). In the final round of analysis two independent raters (R. K. and S. A.-A.) wrote memos summarizing the general characteristics of the textbooks based on integrating all the findings from the first two rounds. Additionally, these memos included both a rating in the sense of curriculum orientation within the textbook (De Jong, 2006; Eilks et al., 2013) and a characterization of the curriculum emphasis as discussed by Eilks et al. (2013), based on Roberts (1982) and Van Berkel (2005). Finally, synthesis of the memos was developed using a dialogic process mediated by another author of the paper (I.E.) until a joint characterization for each of the textbooks was reached. This dialogical process was started by the third author writing each synthesis of the considerations from the first two authors for each of the textbooks. These syntheses were sent back to the first two authors to comment and suggest changes. This process was repeated two times until all three authors agreed the joint description. At a later stage, and to better illustrate the findings, a rating was done by each of the authors concerning the prevailing curriculum emphasis and preferred curriculum orientation in each of the books. There was also a rating on the degrees of contextualization/societal orientation as well as suggested student involvement. In the last two ratings, we decided to use a three-step scale from low (elements and indicators of the corresponding issue are not present in the book or only marginal), via medium (elements and indicators of the corresponding issue are present, but are not used throughout and or as prominent characteristics), to high (elements and indicators of the corresponding issue are prominent features of the textbook). The ratings were given independently by the authors based on all three cycles of analysis, and then compared. A comparison gave an overall clear agreement with only a few points that were later finally rated based on a joint negotiation.

Findings

All of the Arabic textbooks in this sample were published in the last ten years and are still in use today. Viewed chronologically the books were issued in 2006 (Kuwait and Jordan), 2008 (Saudi Arabia), 2010 (Algeria), 2013 (Egypt and Syria), and 2014‑2015 (Palestine). The variety seen in the use of contexts to frame the learning of chemistry is quite wide. This indicates several different curriculum orientations and helps us to identify part of the curriculum emphases such as illustrations and activities. In the case of Algeria, we see a textbook with a low level of contextualization and societal orientation. The chemistry textbook is part of a physical sciences book. The book focuses almost exclusively on chemistry content knowledge as represented by chemical structures and other purely pictorial items. Very few day-to-day issues are mentioned (e.g. at one point molar calculations are related to some clinical laboratory tests). These references are hardly sufficient to classify the book as a contextualization of chemistry within everyday life or society. The structure of the curriculum is composed of the following topics: materials, chemical and physical changes, the periodic table, various geometric shapes of atoms and/or molecules, chemical calculations, and chemical changes via chemical reactions. More recent topics such as nanomaterials and environmental chemistry cannot be found. Much of the content is presented in the form of data tables. Safety procedures are, however, mentioned and represented by small symbols. The images in the text are limited to pictures of a few test tubes, a litmus scale and the flame test color scale for the elements. Very few of the pictures relate to everyday life phenomena like volcanoes. No pictures of people are offered, with the exception of one photo of a woman supervising a lab as a teacher. There are also very few photos of historical scientific figures, only one of whom has an Arabic Muslim background. This was Jabir ibn Hayyan, who is also mentioned in the Jordanian textbook. Almost no languages other than Arabic are ever used. The Algerian textbook provides no suggestions for inquiry-based activities or recommendations for Internet searches, except for one activity focusing on pH values. The broadest use of contexts was found in the Egyptian textbook, which more strongly employs modern, everyday contexts for the learning of chemistry than its competitors. The contextual orientation of the Egyptian book was easy to identify, since it mentions the impact of technology and industry on both everyday life and society. The textbook focuses on modern technological issues like nanotechnology and green chemistry. Current applications of chemistry are mentioned, including the use of carbon nanotubes, water treatment systems, and paper recycling. This textbook includes many issues taken from both daily life and environmental issues. It connects them to chemistry learning, e.g. cosmetic products and the global warming debate. The curriculum behind the book is structured by chapters on the following topics: chemistry as the centre of the sciences (the topic of nanotechnology is discussed in addition to chemistry and measurement), quantitative chemistry, acid‑base solutions, thermal chemistry, nuclear chemistry, and chemistry and the environment (where issues of environmental pollution are targeted). The content in both the Egyptian text and corresponding activity books is clearly illustrated through colorful, high-resolution pictures showing lab equipment, daily life scenarios (e.g. a person filling up his car with gasoline), nature (e.g. a polar bear in its natural environment), as well as images of male and female human beings, among them some historical figures. However, only one modern Arabic scientist is mentioned (Mustafa Alsyed), while all others are non-Arabic. However, all titles, subtitles and keywords are given in both the Arabic and English language. The main ideas and keywords for each chapter are condensed on one page as a chapter suffix and then organized via concept mapping. References in the book are directed to both Arabic and non-Arabic sources, a list of web pages are included, and the students are requested to perform six individual Internet search exercises. There is one religious sign in the text book (concerning the students' appreciation for God's great ability).

Safety procedures and safety rules have also been carefully taken into account, either in written form or as images. The experiments are clearly described and guide students step-by step towards the experimental results. The book suggests tasks to guide pupils to both inquiry-based and analytical thinking activities. In the Jordanian textbook the curriculum is also contextualized and canters around the idea of energy and the possibility that the future may be affected by more limited resources. The main focus concerns the conservation of petroleum and natural gas. At several places, the curriculum contains science-to society relations, for example the topics of biofuel usage and biogas production, including how families can build their own biogas generators. Everyday events and phenomena of life like photosynthesis are used as contexts for chemistry learning. Other units are more overtly aligned with the content structure approach (e.g. by the law of definite proportions, chemical bonds, Lewis structures, valence, ionic groups, etc.). These chapters focus more on science facts and the learning of theories, rather than on promoting thinking in context or learning about science-to-society links. Modern chemistry topics are mentioned only briefly and are located within units which sometimes could have been better introduced with the help of daily life examples. Scientific terms are encountered in the English language and can also be found within the text. This textbook also mentions only one Arabic Muslim historical figure, Jabier ibn Hayyan. All other people mentioned are non-Arabic figures. Modern chemistry is slightly mentioned in very few locations. Contextualization with the aid of images is weaker than in the Egyptian textbook. There are a few simple pictures showing medicine tablets and bread pieces, but images of persons do not appear with the exception of a picture of one 12- to 15-year-old boy. A few chemical apparatuses are provided in sketch form. Any suggestions for Internet searches focus primarily on looking up extra content material like atomic structures, the periodic table and its elements, chemical bonding structures, reactions, formulas, chemical calculations, energy via chemical reaction, and organic chemistry. The textbook from Kuwait is introduced with a photo of the country's prince. This book is the only one where the Koran is mentioned in three locations (describing electron paths, comparing electron orbitals with planetary movements, and mentioning the importance of water for life as supported by a quote from the Koran). The curriculum is quite basic and approached mainly by the structure of the discipline route. The content covers atomic structure and models of the atom, the periodic table and its element groups, chemical bonds, and a study of the elements carbon, nitrogen, and oxygen. Presentation of the content is weakly supported by daily life applications, and only in very few places. One example uses an emission spectrum in the field of forensic scene investigation. Modern issues and pedagogies including Internet searches and learning about laboratory safety are totally absent. The content is illustrated by only very few images and few experimental issues like Rutherford's experiment, carbon dioxide gas collection in the lab, and nitrogen gas preparation. The book does not refer to historical figures with their biographies or their photos. The Palestinian textbook seems to focus mainly on the learning of fundamental concepts of chemistry, too. The central focus is on the periodic table of the elements. This approach seems content with providing students with information on specific elements, listing their characteristics, and connecting these elements to some applications selected from daily life. This is the case for nitrogen, silicon, sulphur, calcium, copper, and uranium. Sketches and figures in the textbook show chemical technology and engineering (e.g. the fractional distillation of liquid air, the Haber–Bosch process, and silicone production). The topics are organized via four units: the chemistry of periodic table elements, chemical calculations, chemical reaction energy, and organic chemistry. Images vary between chemistry in daily life, technical systems, natural phenomena, and references to a few experiments. However, there are no figures with images of people. Some encouragement for pupils to use the Internet is provided, but not much. At one place the book suggests that students perform a more social search by asking them to visit a dermatology clinic or a pharmacy website in order to collect information about the daily use of sulphur. End references are divided into three lists: Arabic references, non-Arabic references and electronic websites. The use of the English language is limited in the book. References to safety procedures and modern topics are completely absent from the text. The textbook from Saudi Arabia is an adoption of the book Chemistry, Matter and Change from the USA. Like Egypt's textbook does, this book includes a student laboratory and activities manual as an additional part of the curriculum. Chemistry is presented in connection with many other scientific domains like zoology and anthropology and with daily life issues and industrial fields such as the nylon industry. Science history is also employed in the Saudi Arabian textbook. Most notably, a female scientist is even mentioned: Lise Meitner. Modern topics of chemistry and environmental issues are mentioned, but only briefly explained (e.g. ozone depletion, nanotechnology). Some topics are somewhat contextualized and related to societal issues (the use of X-rays in medicine). The main themes covered in the Saudi Arabian textbook are chemical materials, atomic structure, chemical reaction, chemical calculations, chemical formula, molecular formula, salt water chemistry, and life. Historical events such as the establishment of CERN in Switzerland in 1954 flow as a template of chronological order, finally reaching the use of nanomaterials after further illustrations are given. The Saudi Arabian book shows people from Arabic society wearing typical Arabian clothing. Experimental work accompanied by safety procedures are strongly presented in the Saudi Arabian book. Technical issues use English words to describe them and the widespread use of historical figures with photos is also present. Keywords are offered at the end of the book with English translations. The great ability of God is mentioned one time in the first chapter of the textbook, as is the case in Egypt's textbook. The Syrian textbook is structured around some theoretical and societal orientations of chemistry. It connects chemistry learning with other subjects, like math, biology, and the Arabic and Latin languages. These connections are made in order to contextualize the proposed chemical inquiries. The topics are also linked to fields such as industrial environments (mainly the petroleum industry), daily life and environmental aspects. Examples for contexts and science-to-society relations include global warming, air pollution, plastic products in the environment, and the desalination of seawater. In this respect the textbook is quite similar to Egypt's offering described above. However, there is a lower grade of practical activities suggested. Historical figures are introduced, as are Arabic scientists of the modern era like Ahmad Zwail. Historical perspectives are not limited to individual persons. References to history are also connected to earlier civilizations and countries, including Phoenicia, Babylonia, Arabia, China and also the USA in the case of early petroleum exploration in America. The book delivers many images of phenomena, daily life issues, physical effects, experiments and graphic schemes. Daily consumables are presented in the text book in order to support ideas like plastic as an artificial polymer or corn as a biopolymer. Many chemical reactions are shown with the aid of images, for example the decomposition of ammonium chromate and the reaction between sodium chromate and silver nitrate. Pictures of people appear in historical contexts more than they present everyday people. Many historical scientists are also mentioned, but very few pictures of them are provided. Only one picture shows someone in the context of industry work (an employee in the petroleum industry). The Syrian textbook gives references mainly to Arabic publications and university textbooks. English words are rarely used. Images which should accompany experiments or safety procedures are completely absent.

Discussion

The sample of seven 10th grade Arabic chemistry textbooks reveals a broad variety of approaches taken towards the chemistry curriculum (Table 2).

Table 2. General characteristics of the different grade-10 chemistry textbooks

	Main curriculum emphasis	Basic orientation(s) of the curriculum	Degree of contextualization and societal orientation	Degree of suggested student involvement
Algeria	Fundamental Chemistry	structure of the discipline	low	low
Egypt	Chemistry, Technology and Society	everyday life, technology and industry, environment	high	high
Jordan	Chemistry, Technology and Society	everyday life, environment, socio-scientific issues	medium	medium
Kuwait	Fundamental Chemistry	structure of the discipline	low	Low
Palestine	Fundamental Chemistry	structure of the discipline, technology and industry	medium	medium
Saudi-Arabia	Chemistry, Technology and Society	everyday life, technology and industry, history of chemistry	high	high
Syria	Chemistry, Technology and Society	everyday life, technology and industry, environment, socio-scientific issues	high	medium

Some of the curricula suggested in the textbooks (Palestine, Algeria and Kuwait) seem to be quite traditional and focus mainly on fundamental chemistry learning (slightly less so in the case of Palestine). These are typical examples of the structure-of-the-discipline orientation of the chemistry curriculum as described by Eilks et al. (2013). The main driver of the curriculum in these three textbooks is the pure learning of chemistry facts and theories. Accordingly, the structure and textual approaches in these books directly parallel the structure and content of academic chemistry textbooks. The level of contextualization is low and there is hardly any focus on understanding chemistry-to society links, or on environmental issues and challenges. This has already been described in the 1990s for a sample of eleven Arabic science textbooks analyzed by Nashwan (1993) and for seven textbooks in Gulf countries selected by Badran (1993). This still seems to hold true for a large part of Arabic countries (see also: World Bank, 2008). Dagher and BouJaoude (2011) described these curricula with reference to Nashwan as follows:

‘’More specifically, these curricula: (1) did not develop students’ abilities to use investigative problem solving and thinking skills, (2) ignored students’ interests, backgrounds and environments, (3) paid no attention to creativity and imagination, (4) did not attempt to address students’ unacceptable beliefs in myths and superstitions and (5) did not help students to understand their bodies and take care of their health and hygiene.”(pp. 78–79)

Dagher and BouJaoude (2011) view outdated curricula as one major reason for the low average level of achievement in science education in many Arabic countries, although comparative data for the average achievement level of students in science education in Arabic countries in comparison to other countries are hardly available. Additional characteristics of science education in selected countries are issues of traditional pedagogies, a limited access to technology, and current assessment practices (see also Al-Amoush et al., 2014). Dagher and BouJaoude (2011) described lacking teacher support and involvement as the main reasons that reforms in Arabic countries have so often failed in recent decades. This was also corroborated by Al-Amoush et al. (2012) for the case of Jordan. The Palestinian textbook connects chemistry learning with technology and engineering, thus having a technology/industry orientation, but still fails to focus strongly on everyday life science issues and the interplay between science, technology and society. There also exist other books like the ones from Egypt and Syria. These books use specific contexts and refer to applications and issues of chemistry found in technology, industry and the environment at least to a certain extent. Everyday life contexts and environmental issues such as global warming are embedded in these countries’ suggested curricula. Mansour (2010) has also described the science curriculum in Egypt as one which is on the way towards including more scientific literacy aspects. Contextualization is also present, but to a lower extent, in the Jordanian textbook. This book provides an orientation around everyday life issues and can be seen as combined with an environmental and technology/industry orientation as discussed in Eilks et al. (2013). This textbook has the clearest connections to proposed solutions for environmental challenges. It might be interpreted as one of the few orientations towards societal challenges and socio-scientific issues identified in the current study. The Saudi Arabian textbook represents a special case, because it is a translation and adaptation of a book from a Western country. This book is close (possibly superior) to the group of books from Egypt and Syria.

However, it is hard to say to what extent these curricula are carried out in the way intended by the governmental school systems. The analysis by Dagher and Boujaoude (2011) suggested that, even if reforms are intentionally introduced via textbooks, they often fail because of lacking support among teachers. The different curriculum orientations (De Jong, 2006) arealso in line with the issues of textbook illustration and choice of pedagogy. Indicators for this include the use of pictures, activities and end references (Devetak and Vogrinc, 2013). In the textbooks from Egypt, Syria, Saudi Arabia and (to a lesser extent) Jordan we could identify more illustrations taken from everyday life and of human beings in the context of chemistry than in the other textbooks. We could also see more suggestions for practical work and incorporating the Internet into chemistry learning. There were also more references to other scientific domains and explicit discussions of safety issues. This occurs to a much lesser extent in the textbooks from Algeria, Kuwait and Palestine. The curriculum emphasis in the different textbooks varies widely. Referring to Van Berkel's (2005) three curriculum emphases, we can see that the Chemistry‐Technology‐Society emphasis is prevalent in textbooks from Egypt, Syria, Saudi Arabia and (to a lesser extent) Jordan. Such textbooks making connections to societal issues generally have proven to be more appealing to both students and teachers (Van Griethuijsen et al., 2014). The books stemming from Palestine and, most especially, from Algeria and Kuwait represent a curriculum emphasis on Fundamental Chemistry. In this case learning chemistry is placed first, so that later learning and comprehension of relevant applications and issues related to chemistry can be realized as a gain of knowledge. The curriculum emphasis of Knowledge Development in Chemistry, which is related to inquiry-based learning, is touched upon in all the textbooks. But a focus on the curriculum emphasis of Knowledge Development in Chemistry remains very limited in all the books (as seems to be generally the case in science education in many Arab science curricula, e.g., Dagher et al., 2010; Mansour, 2010). Elements such as how and in which socio-historical context chemistry knowledge emerged and the overall nature of science somehow get lost in the mix. This is especially true for the case of references to socio-historical reflections on the history of chemistry. In all of the books, reflection upon the history in science in Arabian lands is widely neglected when it concerns both historical and more modern developments. This study purposely selected textbooks from Arabic countries which embodied varying characteristics. However, no clear relationship could be found between certain characteristics and the intrinsic nature of the chemistry textbooks. The more modern type textbooks in terms of contextualization and reference to society and the environment come from countries which consider themselves as being relatively secular (Jordan, Syria and Egypt). However, the same is true for Saudi Arabia where religion and traditionalism play a much more important role in society. We can also see no connection between the socioeconomic conditions and how traditional the chemistry curriculum is, as we do not find a regional impact. This can be seen from comparisons between Egypt and Algeria, Saudi Arabia and Kuwait, and Jordan and Palestine. It seems that none of the clear differences gives any indication in which direction the chemistry curriculum is suggested to be operated.

Conclusions and limitations

One explanation for the finding of the large variety in the intended 10th grade chemistry curricula among the seven Arabic countries is the low influence of society on the development of national curricula, upon which basis textbooks are written. Dagher and BouJaoude (2011) describe the setting of science curriculum goals in many Arabic countries as a centrally-controlled process, which occurs in ministries of education or related administrative bodies. They describe that

this process is: "rarely an outcome of democratic negotiation between various stakeholders. A transparent, public and open process for achieving consensus around curricular goals/standards like that undertaken in the USA [. . .] is not the norm in Arab states. The more pervasive top-down approach to determining and disseminating curriculum mandates precludes a broader base of participation by teachers, teacher educators, and scientists, as well as community members.''(p.80)

It is recommended that the process of development of the chemistry curricula is reflected especially in those Arabic countries which still operate very traditional approaches of the intended chemistry curriculum in their textbooks. It should be reflected why more modern approaches are not in use, why modern issues and applications of chemistry are absent in the intended curricula, e.g. in Algeria and Kuwait. Maybe countries with more traditional intended curricula can learn from those with more modern approaches. This is related to what we also can recognize from the study: four of the textbooks represent at least a slight orientation towards modern types of intended chemistry curricula in terms of situated learning theory (Greeno, 1998). These books relate the learning of chemistry to everyday life, societal and environmental issues. The degree of contextualization in these four textbooks from Egypt, Syria, Jordan and Saudi Arabia varies, but is considerable. The inclusion of modern chemistry content and suggestions for student-active learning also vary. In any case these four textbooks can be considered to offer learners opportunities to understand the broader picture of chemistry and its impact on life, technology and the environment. These books show that the approach towards more modern chemistry curricula is possible, even in the context of poorer or less secular Arabic countries, like Egypt or Saudi Arabia respectively. However, also these countries might reflect whether the degree of contextualisation and societal orientation in their textbooks corresponds to the state-of-the-art for modern chemistry education and whether there is a chance to better include also the curriculum emphasis of Knowledge Development in Chemistry. However, this study cannot reveal how the textbooks are used and operated. It cannot say how intensely teachers use the contexts provided in some of the textbooks or whether teachers add contexts and information on applications of chemistry by other media in those cases where the books do not provide them. The same holds true for student activities. The study is also limited since it just provides a rather general view on the intended curricula and pedagogy as represented by the textbooks. More in-depth analysis in the future might also compare more specific details, e.g. specific representations of certain knowledge domains, approaches towards the nature of science, or the use of the different representational levels of chemistry. A final limitation lies in the fact that only the 10th grade chemistry textbooks were analysed. This does not allow us to reveal any information about which picture of chemistry or science is provided in the textbooks of other grades, i.e. on the lower secondary level. Further research is also needed on the alignment of educational policy documents and intended curricula with the curricula which are really taught, learned and assessed in these countries (Dagher and BouJaoude, 2011).

Appdendix 1: Overview about selected formal characteristics of the seven textbooks

Country	Title	Authors	Year of issue	Number of pages	Number of figures/tables	Number of suggested experiments
Algeria	Physical Science	Bu Shafea, I. Mazzooz, A. K. Ben Wareth,A. Ben Issa, A. Azzizo	2013	105	3/50	25
Egypt	Chemistry	S. W. Sadek, M. A. Abu Lila, I. M. Sayed, N. M. Shalabee, H. M. Hasanean	2013	(text-book), (activities book)	2/17	35
Jordan	Chemistry	A. M. Ajloonee, M. M. M. Alzoubee, A. M. Msaeda, Y. M. Omari	2006	188	1/40	18
Kuwait	Chemistry	Y. Algneam, F. Alrweah, S. A. H. Ahfood,A. M. Mansour, F. I. Fihmee, A.A.H Alsadek	2006	180	5/24	7
Palestine	Chemistry	F. Rimawee, S. Shlafaa, F. Yasin, A. Mydanee, F. Yousef, M. A. Asba	2014	100	2/17	24
Saudi Arabia	Chemistry	T. Buthelezi, C. Wistrom, N. Hainen, L. Dingrando, D. Zike and others	2008	(textbook) (activities book)	4/38	37
Syria	Chemistry	Shawa, B. Mhana, A. Nadaf, Y. Hamad, F. Kandeel, N. Machol, A. Kaadan, Y. Atassee	2013	188	4/19	25

Chapter 3: The operated curriculum and pedagogy – An interview study with eighteen randomly selected chemistry and physics teachers in Syria

The operated curriculum and pedagogy – An interview study with eighteen randomly selected chemistry and physics teachers in Syria

This case study aims to identify teachers' perceptions of teaching chemistry and physics in Syria by investigating their views on using information and communication technology, operating practical work, approaching the nature of science, and perceiving the curriculum that has been recently changed. The sample consists of eighteen randomly selected teachers from eight different secondary schools in Damascus, Syrian Arab Republic. The sample varies concerning gender, age, years of teaching experience, and type of the public or private working environments. Semi-structured interviews were performed for data acquisition. The results indicate that more than half of the teachers use ICT (Information and communication technology) systematically, especially to show videos, but less than half of the teachers operate laboratory work. The results conclude that less than half of the teachers are satisfied with the curriculum. This is mainly because of content overload, a too theoretical approach, and low levels of contextualization. Overall, teachers can be categorized into two main groups. The first group of teachers can be described as being dynamic and open to reform while the other group is more traditional and less open to any reforms. Gender has no effect on this categorization but there is a strong correlation with the age of the teachers, their years of experience and the type of work environment that they are exposed to. There are various obstacles that prohibit reform these are: problems in infrastructure, crowded classrooms, lack of time, lack of order in laboratories, and poor salaries. There also seems to be a strong lack of continuous professional development for science teachers.

Introduction

Science education research studies are relatively rare in most Arab countries. There are just a few studies via Master's theses, e.g., in Oman or Morocco. Such studies deal among others with effects of teaching methods, like problem-based learning (PBL) (Amador, 2004). Science education research in Jordan (Al-Muhtaseb & Al-Weher, 2009) and Lebanon (BouJaoude, Abd-El-Khalick, & El-Hage, 2009) is more active. Research in Jordan focused, among others, on the effect of instructional strategies, like inquiry and discovery learning (Prince & Felder, 2006), problem solving, learning cycle analysis, scientific hands-on activities, the history of science, mastery learning or brainstorming as well as classroom discourse (Al-Khatib, 2012; Chamizo, 2012; Kotob, 2006; Seroglou & Koumaras, 2001). Systemic approaches for teaching, using probing questions, individualized teaching, advanced organizers, storytelling, integrated methods (Allchin, Andersen & Nielsen, 2014) computers, authentic assessment, writing-to-learn strategies, or using Marzano's model on developing higher-order thinking skills (Marzano, 2013) were further foci. The latter strategy is highly required to be employed by qualified teachers but many Arab countries suffer from low quality teacher education, especially in those countries that have relatively low salaries and limited opportunities for professional development (Al-Amoush et al., 2012).

The teacher is the essential actor in any educational process, and therefore investigation on teachers' prior knowledge, performance and beliefs should be deeper (Haney, Czerniak & Lumpe, 1996; Trigwell, Prosser & Taylor, 1994). Future chemistry and physics teachers in Arab world countries generally graduate with a minimum level of teaching experience and enter their profession with deficits in academic preparation and professional development (Faour, 2012). This leads to limitations in teachers' level of knowledge and practical experience, when they are officially employed, unless they have personally acquired further knowledge and practical experience. Therefore, deeper and broader understanding of teachers' cognition is urgently required about how to affect teachers' beliefs and help them for professional growth to strengthen the chance for success in educational reform (Yerrick & Roth, 2004).

One field for reform and professional development is suggested to be the use of modern information and communication technologies (ICT). ICT is widely emphasized by educational policymakers to improve individuals' capability to become competitive in a global economy by creating a skilled work force and facilitating social mobility (Kozma, 2005). ICT can help students' learning of content knowledge, engaging them in constructing their own banner, and support the development of complex thinking skills and thus compensate shortcomings in teacher knowledge and pedagogy (Kozma, 2005; Kulik, 2003; Webb & Cox, 2004). Moreover, it is also suggested as a substitute to laboratory work if teachers are not ready prepared to do it or laboratories are not available at all (La Velle, McFarlane & Brawn, 2003). But, according to the research of Al-Amoush *et al*. (2012) shortage of time leads to the situation that many teachers in Arab countries tend to rarely apply any student-active pedagogies in class, neither by ICT nor by practical work. However, ICT alone cannot create a modern teaching and learning environment. In most Arab world countries, where the main emphasis of the chemistry and physics curricula is still on pure theory and the structure of discipline, (Nashwan, 1993) better operation of situated cognition and thus contextualized learning is needed (Greeno, 1998). This needs to be supported by teaching instruments which provide approaches to contextualize the huge quantity of theory. ICT and practical work can provide tools to do so, especially when students are shown video about scientific topics or performing experiments related to their life.

The use of laboratories should be oriented towards students' epistemic knowledge development, by employing the laboratory to create relevant science education that helps developing students' mental skills, encouraging their powerful enthusiasm to participate in society, in the present and future. The lack of experimental experiences might negatively influence students' motivation, enjoyment of the subject, and reduce the number of students continuing science and engineering studies (Barnea, Dori & Hofstein, 2010). A more constructivist and humanistic orientation is suggested for modern science teaching under inclusion of the chemical laboratory, integrating students' affective, cognitive, and psychomotor progress by showing how humankind is influenced by the development of science and how innovation is being judged along time (Nisbett & Ross, 1980). This can be done through the inclusion of learning about the history and philosophy of science. The history of science can be used to learn scientific content as it emerged in the past accompanied by the historical development of humankind and society (Eilks, et al., 2013). In a research project from Jordan, teachers complained about their intended curricula that were mainly focusing on the rote learning of chemistry as facts and theories where everyday life contexts or the history of science were both missing (Al-Amoush et al., 2012).

Hence teachers are needed to be included in any reform processes for effective changes in the curriculum and pedagogy and therefore it is imperative to take existing teachers' views into consideration (De Jong, Veal & Van Driel, 2002; Eilks, Ralle, Markic, Pilot & Valanides, 2006; Justi & Van Driel, 2006). Also in the Arab world, teachers are suggested to be active participators in curriculum development. Thus, also in Arab countries corresponding continuous professional development (CPD) which develops teachers' professional knowledge and knowledge about any intended reform is needed (Al-Amoush et al., 2012). This CPD has to jointly focus all the three teacher knowledge domains, namely subject matter knowledge, pedagogical knowledge, and pedagogical content knowledge as suggested by Shulman (1986). An additional domain is personal practical knowledge as suggested by Beattie (1995) for which hardly any information is available in the case of Syria.

Although there is some knowledge available on teachers views, beliefs and knowledge in the international literature concerning, e.g. Lebanon, Jordan or Saudi-Arabia, there is hardly any evidence documented in the case of Syria. The reason is not totally clear but what is known is that Syria is documenting most of its educational research in Arabic language studies. Only rarely is educational research documented for the international scientific community. This exploratory study aims to provide evidence on selected aspects of teachers' views on science teaching practices in chemistry and physics education in Syria for an international audience. Foci of the study are teachers' use of ICT, operation of practical work, approaches to the history of science, and the teachers' perception of the intended curriculum which has been recently changed now suggesting better visualization and more questions and problems. For this purpose, eighteen Syrian chemistry and physics teachers have been interviewed in secondary schools in Damascus. The teachers vary in gender (8 male and 10 female), are aged between 20 and 60 years old, have between one and 35 years of teaching experience, and work in different environments (public sector, private schools, and, among the latter, one United Nations school).

Theoretical framework

The first part of the study has three main foci, the first being the extent to which Syrian teachers integrate ICT, experimental work and the history of science into their chemistry and physics classrooms. The second focal point will be to explore the teachers' perception of the intended curriculum in chemistry and physics teaching and how it is to be operated. Finally, the study focuses whether different types of teachers can be identified.

Integrating information and communication technology (ICT) effectively in any pedagogical process is a challenge teachers and educational authorities are faced with (Christensen & Knezek, 2008). Technology is increasingly invading every aspect of our lives, influencing attitudes and lifestyles. Similar to the case of daily phone calls, e-mail could be routines or habits where the students send emails whenever they get a chance to use the computer (Dordick & LaRose, 1992). Another example of how media shapes students perceptions of science comes from the various types of programs that are available to students. Programs like documentaries, magazine articles, YouTube videos, and TV-programs provide students with different perceptions on the nature of science (Dhingra, 2003). These programs often allow students to understand that scientific results might be up to interpretation which is valuable for critical thinking (Dhingra, 2003). It is important to be able to assess input critically because often television viewers are sometimes confronted with jaded or compromised information (Nisbet, Scheufele, Shanahan, Moy, Brossard, & Lewenstein, 2002). Scientifically literate people are more skeptical of the world. Nisbet et al. claim that newspapers are usually a better source for the acquisition of scientific knowledge while media sources such as television programs tend to portray scientists in a more biased light. The integration of such resources into the classroom motivates the students to learn and is very memorable but must be done carefully, in parallel to this integration students also need to be taught not to take facts at face-value. Since it plays such a large role in everyday life it is unavoidable that also modern ICT becomes integrated into science education. Incorporating technology can facilitate the process of information access and learning. It can also provide teachers and students with up-to-date information to enrich their experiences and knowledge acquisition (Juuti, Lavonen, Aksela & Meisalo, 2009). However, the pedagogical adaptation of ICT is not an easy mission. It faces numerous difficulties and obstacles. Some teachers suffer from the lack of proper equipment (modern computers and software) and the unavailability of professional technicians who can maintain the equipment in good condition. Another issue worth mentioning is teachers' insufficient time and experience (Al-Amoush et al., 2011).

If ICT is successfully applied in pedagogical practices without obstacles and barriers there is chance to promote collaboration skills in class (Bingimlas, 2009). The internet can be used both as a source of information and a tool for communication between teachers and students, as well as among students. Teachers and students can have fruitful discussions about scientific questions like analyzing videos about a specific chemical phenomenon or an article about some new exploration in the science domains (Bingimlas, 2009). Open use of ICT can also enhance students' tendencies towards research and encourage them to be an active part of the learning process rather than being passive receivers of knowledge. With the help and guidance of teachers, students can take responsibility for their own learning and will begin to self-evaluate their performance while teachers engage them with productive ICT activities (Lavonen, 2005). Unfortunately, the idea of implementing ICT in science teaching has not been fully crystalized in the Syrian educational system as in many other Arab countries (UNDP/RBAS, 2003). The Syrian civil war since 2011 has added additional obstacles to the implementation of ICT. Even if teachers are trying to engage ICT in their teaching, they often do not have the required equipment, and software, Internet availability, or electricity breakdowns hinder their chances.

Chemistry is an applied subject that requires experimental work and activities (Eilks et al., 2013). For more than a century, lab activities have been suggested for science teaching as necessary classroom activities (DeBoer, 1991). Laboratory activity is an essential part of every modern science course due to the nature of science (Hofstein, Abrahams & Kessner, 2013). Students are expected to understand the natural world if they work directly with natural phenomena, using their senses to perceive nature and using tools to outspread their senses (National Science Board, 1991). Practical work can arouse curiosity, interest, and achievement in science. In order to foster this curiosity, more activities and skills should be involved, focusing on the enthusiastic investigation of knowledge and understanding of unusual elements in the environment (Haury, 1993; Maw & Maw, 1965). An example of these activities could include any type of laboratory work in the sciences and an integration of active experimentation into science teaching. During experimental work, students are not only receiving theoretical information but they are witnessing and participating in hands-on activity thereby having great opportunities to learn science in practice (Lehrer & Schauble, 2006). Practical work can also improve students' creative skills while establishing assumptions and suggestions about the result of any experiment or chemical reactions. In addition, laboratory activity has the potential to develop students' abilities in observing the given information and analyzing the results (Hofstein & Lunetta, 1982). Experimental applications can help students to connect science with their everyday life by providing meaningful and applicable knowledge and enabling them to put abstract information into practice (Harman, Cokelez, Dal & Alper, 2016).

In order to successfully achieve the goals of experimental work, teachers must have adequate capabilities in the field of preparing the laboratory environment and dealing with lab tools and chemical materials. Teachers must have the ability to manage the class during lab activity especially if they prefer to engage students with hands-on experiments (Yildirim, 2016). If available, lab technicians have an essential role in lab work, as they prepare the lab and the necessary equipment and material that are necessary for each experiment and reaction. Lab technicians know how to maintain materials under safe conditions, and under conditions that will extend the lifetime of the materials. The maintenance of the materials by the teacher or an educated lab technician is vital for the learning of the students since without the proper conditions materials might come to be completely useless. Teachers and technicians also need to check for any shortage in the materials and inform new teachers about the proper usage of equipment and materials. In fact, teachers and lab keepers are not the only factors that play a vital role in accomplishing practical work, as the curriculum must also consider laboratory application and obligate teachers to perform experiments to concentrate students' attention (Ulukök & Sari, 2016). Teachers and lab technicians are also responsible for managing lab safety and informing students of the dangers associated with using chemical materials. They set safety rules that need to be followed before entering the lab like the mandatory utilization of lab goggles, aprons or gloves (National Science Teachers' Association, 2013).

The university teacher education programs in many Arab countries do not equip teachers to perform adequately in secondary school classes; for example in Jordan, secondary teacher qualification depends on pedagogical workshops in the first actual year of teaching after the Bachelor's degree (Al-Amoush et al., 2012). It is suggested that teacher trainers should have a educational Master's degree and some teachers are now starting to attain this level of education (Qablan, Jaradat & Al-Momani, 2010). The pedagogical workshops accompanying the initial stage of a teacher's career should concentrate on teaching methodology, different types of assessment, performing experiments within the educational context, and other educational issues. However, in some countries these workshops are very limited scope and time (Al-Amoush et al., 2012).

The knowledge of chemistry teachers should start from the chemical composition, structure, properties of substances, chemical processes and the transformations that they undergo. This includes the uses of chemicals, interactions, danger signs, safety rules, production techniques, and disposal methods. However, the background knowledge of teachers should also encompass pedagogical content knowledge (Shulman, 1986). This is knowledge of the pedagogy, principles and methods for curriculum and training design, teaching and instruction materials for individuals and groups, assessment, or the nature of science, as e.g. summed up in Eilks and Hofstein (2013). Several skills are fundamental and pedagogical ones have the same level of importance as content knowledge. Domains of teachers' skills are wide-ranging including their ability for speaking and talking to students to convey information effectively, showing a high level of communication skills to solve problems, using logic and reasoning to identify the strength and weaknesses in each situation, or approaches to the problems in several manners, among them the history and nature of science. In many papers, the history of science is considered an essential component in teacher knowledge to give the teacher a feeling of the domain they are teaching about (McComas, 1998). In class, the history of science can have positive effect on students' observation skills and their meaningful comprehension of science (Chamizo, 2012). The history of science can effectively enhance students' perception of science if it tackles scientific characteristics and frameworks while narrating prominent scientists' stories, their achievements and the hard path they took to accomplish their explorations and inventions (Abd-El-Khalick & Lederman, 2000). The history of science can also help students to understand the origin of scientific principles, their developments and related explorations and theories. In addition, it raises students' awareness of the fact that scientific theories and concepts are constantly changing in the light of new research and that there are no static notions in science (Nersessian, 2002). However, the history of science, if not well presented and justified, appears to be a raw and uninteresting matter, both to some students and teachers (Eilks, Möllering, & Valanides, 2007), or can be even the source of misunderstandings and learning difficulties (Eilks, 2013). So, teachers must have a motivational approach to attract students' attention to the history of science, e.g. by using videos and Internet searches or to replicate historical findings in the laboratory. Teachers can present this subject in an interesting manner using ICT based slide shows, interactive quizzes, or flash cards in order to encourage students to absorb information and react with the lesson (Eilks et al., 2013). However, if the teachers feel overwhelmed by overloaded curricula, the history of science might be among the first issues to be excluded from the teachers' pedagogical plan, since it often is not part of the corresponding assessment.

Teachers' view of the intended curriculum is also an important issue to discuss. The curriculum is considered the main and official source of information that guides students and teachers through the pedagogical process. School textbooks are the representation of the intended curriculum. Intended quality curricula must have specific criteria in order to be convenient and clear for both the curriculum and the corresponding textbook (Devetal et al., 2013). Information presentation must be logical, correct and rational in a way that it allows students and teachers access to the information straightforwardly. Proper and modern curricula must not give pure theoretical knowledge directly to students, but encourage them to search and solve problems to attain information individually with the guidance of teachers and textbooks (Eilks, Rauch, Ralle & Hofstein, 2013). This method will guarantee more stable information which is obtained by understanding and not rote-memorizing only (Greeno, 1998).

A good and relevant curriculum must take into consideration the level of the students, their educational progression, level of scientific understanding and their previous schooling experience (Stuckey, Hofstein, Mamlok-Naaman, Hofstein & Eilks, 2013). It is important to use simple and unsophisticated language with clear and organized topics and subtopics, and to eliminate all foreign and complex terminologies in order to achieve higher levels of understanding amongst students. (Markic, Broggy & Childs, 2011). In order to achieve higher cognitive processing levels among students, curricula must stimulate students' attention with more questions, paper pencil tests, activities, and tasks and from different perspectives (Stuckey et al., 2013). Therefore, it is important that teachers accept and reflect the curriculum and are aware about the different orientations and emphasis the science curriculum has, or might have. In detail, modern school science curricula must integrate issues from everyday life, society, the philosophy and history of science, and scientific research (Eilks et al., 2013). These factors support creating a curriculum that suits all students with different cognitive abilities as well as diverse interests and it also eliminate inflexibility and redundancy (Van Berkel, 2005).

Overall this study wants to contribute to understand teachers' views on the use of ICT and practical work in chemistry and physics teaching in Syria, how they operate the history of science and what their general perception of the curriculum is. The following research questions can be derived from the outlined theoretical framework:

Research questions:

a) *How far do Syrian teachers integrate ICT, experimental work, and the history of science in teaching chemistry and physics at the secondary schooling level?*

b) *What is the general perception of teachers of the intended and operated curriculum for teaching chemistry and physics at the secondary schooling level?*

c) *Is there any relationship between the different teachers' views related to gender, age, years of experience, type of work environment?*

Sample and method

Sample

The sample of participants consisted of eighteen secondary school teachers of chemistry and physics. The interviews were done in eight randomly selected schools that are distributed in Damascus, the capital of the Syrian Arab Republic. The sample of this study consists of 8 male and 10 female teachers aged between 20 and 60 years old. The level of experience varies from one to 35 years. Concerning the type of work environment, ten teachers are working in governmental schools only while eight are working both in governmental and non-governmental schools simultaneously. All the teachers who were interviewed were teaching chemistry and physics from grade 7 to 12, but the common denominator is that they are currently teaching 10th grade classes in the scientific branch of the Syrian educational system. Table 1 summarizes some background data about the teachers.

Table 1. Background data of the teachers

Characteristic		Number of teachers
Gender	Male	8
	Female	10
Age	20-30	2
	30-40	11
	40-50	2
	> 50	3
Experience	< 8	3
	8-15	9
	> 15	6
Sector	Governmental only	10
	Governmental & others	8

Method

The study is based on semi-structured interviews which were developed according to the research questions (Table 2). The interview guide deals with questions on ICT, practical work, the history of science and teaching, and teachers' perception of the intended and operated curricula. The interview guide was developed and refined in the English language by several rounds of validation within the research group. Finally, the interview guide was translated into Arabic for use in Syrian secondary schools. The interviews were conducted in Arabic within the teachers' school environment with permission from the Syrian Ministry of Education. Each interview lasted for on average 30 minutes. The interviews were audio-taped and transcribed. The interviews were co-coded by two Arabic native speakers. The processes of inductive and deductive coding were utilized following the principles of qualitative content analysis (Mayring, 2000). Both coders listened to all of the interviews. The coders both came up with a list of points in English that best addressed the questions at hand for each of the topics (Table 2). After listening to each of the interviews the coders discussed the validity of their translation and inductive reasoning and came up with one underlying idea that would best describe what the interviewee was trying to say. During the comparison of the intercoder transcription inter-subjective agreement was reached upon through an iterative process (Swanborn, 1996).

The interviewees were coded in the following manner to allow connecting findings and example quotes with backgrounds of the teachers: The first part of the code indicates which sectors the teacher has worked in public (P) or public and private (PP) sectors. The next part of the code indicates the gender of the interviewee M for male and F for Female. The second to last and last parts of the code represent the age and the years of teaching experience that the interviewee had respectively.

Table 2.Overview about the interview guide

Topic	Questions
ICT, Information and communication technology.	How do you use ICT while preparing the lessons?
	How do you use ICT within teaching in class-room environment?
	How do you guide the students to use ICT?
	What are the obstacles that prevent ICT use?
Experiment works (laboratories)	Do you use laboratories or any type of experimental issues within teaching?
	How do you visit the lab regularly?
	What is the role of students in experiments?
	Are chemical materials available in the lab?
	Do you use safety procedures?
	What are the obstacles that face laboratory usage?
HOS, History of science	Do you mention history of science while teaching?
	What do you focus on?
	What do you think about the science curriculum?

Teachers points of view towards science	How do you find the present curricula compared to previous ones?
	How do students interact with chemistry curricula?

Findings and discussion

The findings of the study show that ICT is well-appreciated among the teachers. 13 out of 18 teachers use ICT regularly, and most teachers agree that ICT should be integrated into the classroom:

"Teachers must be efficient in ICT usage." (PP.M.35.13)

Several teachers include ICT in their course materials by sharing the information gathered from educational websites. Accessibility to computer laboratories is ensured for the students at schools where this privilege is readily available. However, the teachers also described facing several difficulties in applying ICT because of infrastructure damage caused by the civil war:

"We don't ask students to do research using the Internet. We were planning to operate the world link style and paper magazines. I believe in students' ability to go further information than in the current curriculum and do searches. However, the shortage of time, electricity lack and unsafe places are suspending such activities. Videos demonstration are used in physics more than in chemistry, but currently students are not being guided to use Internet." (P.F.38.15)

"As in-service teachers, we have been subjected to training workshops which have been prepared by the Ministry of Education to elaborate ICT use within schools classes but our activity are suspended after the Syrian crisis that negatively affected electricity and Internet service." (P.F.57.28)

A lot of other teachers also confirm that the lack of electricity is a real hindrance:

"*In the meantime, using technology in the pedagogical process is very limited, as electricity is not available all the time. Before the crises we used PowerPoint presentations and some videos."* (P.F.38.15)

"Once we have electricity, we use the projector in order to display PowerPoint slides. I am taking my projector and my laptop to classes in order to support questions and answers with some online experiments or PowerPoint presentations." (PP.M.34.11)

A lot of teachers try to deal with the difficulties posed by the conflict in various ways:

"*Activated online Internet is not the only way to use ICT as a pedagogical tool. For example, some required links could be prepared and saved by the teachers before and then allowing the students to preview them. Moreover, CDs and USB sticks are available and distributed for free by the Ministry of Education to enhance our demonstration skills. I am willing to use the style of school world link in the technology lab, but after the crisis started such activity was cancelled especially that some labs of technology* (sic) *have been transformed into refugees' shelters."* (P.F.35.12)

The crisis has also affected the ability of the teachers to integrate laboratory hands on teaching into their lessons:

"*Some students would like to search on the Internet."* (PP.M.32.8)

"We don't have Internet service at school. If we had Internet, we need to have up to 25 students in class to form interactive classes. However, we have 50 students in the class, so how to apply this? We can't use searching websites in our classes. Before the crises work was a bit easier. We have had technology labs that are not active anymore at the moment." (P.M.54.25)

It is a shame because sometimes the teachers do want to be able to make this integration but are, unfortunately, prevented from doing so by their own circumstances:

"I came to Damascus as a safe city from another city in the north east of Syria. I don't mind guiding my students to use the Internet. Indicating that the school is provided with technology lab like most schools in Damascus, even though, they are not used regularly. Students are used to leave school earlier especially at the end of day, especially after the crises started. We don't have labs. We don't have a technology lab (computer lab). Internet is not available at our school or at student's houses." (P.F.42.17)

When checking for the views of teachers in relation to the gender and age factor the findings present that out of eight male teachers, seven practice the application of ICT while only six out of ten female teachers employ ICT in their teaching methodology:

"I prefer chalk and board teaching, I don't prefer ICT usage because I find it is as a waste of time while accompanying a huge number of students to the computers' lab. In addition, some of students might find a chance to play instead of doing the required searches. My ICT usage attempts appear in displaying few experiments and pictures from the Internet." (P.F.42.18)

One out of two teachers between the ages of 20 to 30, all teachers between the age of 30 to 40 and one out of two teachers between 40 to 50 years of age use ICT within teaching despite the difficulties that they are faced with:

"We used to ask students some questions and that they need to search for the answer online. This technique that enhance students' metacognitive skills and helps them to understand better. Even before the crisis started, Internet was not available for all students at homes. The big number of students prevents us from accompanying them to technology lab." (PP.M.34.11)

The teachers that we interviewed from the above mentioned subgroups all agreed on the importance of ICT integration in the school classroom:

"ICT contributes to critical supervision by developing students' multidimensional ability to use science tools and technology devices in the same laboratory where the teacher is meeting the students not the opposite. I am always encouraging students to do extra researches while avoiding any type of complexity and concentrating following fun and beneficial topics. Scientific concepts can be viewed via internet. Internet could be also an affective compensation when some experimental tools are not available. Our achievements are evaluated annually within special folder that contains the year plan and ICT students' research." (PP.M.26.12)

On the contrary, none of the teachers above the age of 50 utilizes ICT. According to the number of years of experience gained by the teachers, two out of three with less than eight years of experience prefer using ICT in classrooms while all nine teachers experienced between eight and 15 years old and one out of six teachers with more than 15 years of experience are utilizing ICT in science teaching. In relation to the type of work environment, ICT is popular with teachers employed by non-governmental (private and United Nations) schools:

"I asked students to make PowerPoint presentations, or video experiments as student's activity. We show these experiments to students' using projector. I have got comprehensive beliefs about the well pedagogical process and the goals of ICT usage, either by techno-laboratory demonstration, electronic CD-s library or by using teaching videos taking into account restrictions like time and equipment lack. Sometimes I like guiding students to do such independent activities such as research, personal presentation and online communication. By using those activities, I encourage my students to be active learners by depending on themselves and achieve independent knowledge. I always encourage students to seek knowledge without fully depending on their teachers or a certain curriculum." (PP.M.35.12)

All eight teachers working in private schools use ICT in their teaching. On the other hand, only five out of ten teachers working for governmental only schools use ICT. While teachers may sometimes use it to enhance their own abilities they do not integrate the usage of ICT into the classroom:

"I am using the Internet just to enrich my knowledge in certain topics, but the students' Internet usage is also limited or rare. I am not using the Internet in class. "(PP.F.30.6)

Some of these teachers find that sometimes it only serves as a distraction and prefer to let the students use such resources in their own time:

"We are not using the Internet or ask students to use it, but once I have a good resource (video) I give it to students on their USBs to watch it later. Students are not motivated to study in the 10th grade and they consider it as a year to have some fun." (P.M.25.2)

The teachers that tend to exclude ICT from their classrooms tend to have old-fashioned or more traditional views on education:

"The Internet is not used although the new curriculum refers to Internet usage, but we both teachers and students don't use it. We use Internet once in the semester in the Internet hall. I justify that by the heavy curriculum and the crowded classes. My pedagogical view is well experienced due to my long years in teaching, but in general I tend to use the traditional methods in teaching." (P.F.58.30)

"Students are more skilful than us in ICT usage, hence classroom time should be only consumed for curriculum clarification and it is difficult to load ICT activity which could be achieved by students themselves at home. This activity will develop the students' skills which could transform students into active participants in the learning process. Unfortunately, this type of performance could be achieved by low percent of students who are curious and ambitious." (P.F.25.6)

"I had started my teaching in rural areas, and I am one of the science teachers who have outstandingly high potential to offer activities even if materials in laboratory are limited. A world link style has been used in technological laboratories plus you-tube videos-net images-beforehand prepared links are provided, but the crowded classroom is being an obstacle in my way." (P.F.36.13)

"It is difficult to use the Internet, because of electricity issue, and not all schools have projector in the last two years. I have a personal website where I can upload my resources for the lessons, and the students can visit it anytime. In our books we don't have any request to visit websites." (PP.M.32.8)

Practical work in laboratories is highly important and beneficial for learning in the field of science, primarily for subjects like chemistry and physics. The findings of the study show that out of eighteen, only 7 teachers include laboratory work in their courses. Sometimes despite having well-equipped labs, teachers stated that they were unable to utilize them to the best of their ability:

"We have well equipped labs that contain tools and materials. However, teachers are not able to work with them. Additionally, teachers don't have time to prepare for the lab. Lab work should be after the theoretical part. Students visit the laboratory for demonstration Once or twice in the semester. Hands-on activities are absent from our schools and universities. Students enjoy the lab work. Teacher experience and time can increase the usage of lab. I have pedagogical beliefs due to my long experience, but I used to deal with classroom environment away from laboratory. Here in Syria teachers' experiences are weak. Professional teachers are required to train students in laboratories." (P.F.58.30)

Sometimes the large class sizes pose difficulties and despite having the necessary materials teachers often do not have enough for everyone:

"Experiments are not done in labs, but I draw the experiment and explain. I confesses the good equipped laboratory, but I complain about its un-readiness to be used due to poor preparation and the crowded classroom. Referring to the easier implementation in the field of physics' experiments which mostly performed in classroom supported by some drawing on the blackboard." (P.F.33.8)

While some really simply lack the resources in addition to overcrowded classrooms:

"We don't have labs or even technology lab (computer lab). There is a lab with simple things. In my previous school we used to make experiments. Students like to see experiments, and they won't forget the information said there. Currently the situation at a time of crisis is chaotic because her school is used as a refugees' shelter with no labs or any equipment." (P.F.42.17)

Oftentimes even if the resources are available, materials are often out dated:

"In labs our materials are expired (not working), so displaying video experiments (from the net) is more useful. Sometimes we start with experiment then conclusion, on other times we start with conclusion, then experiment. I like practical works by confirming videos popularity. I justify being away from laboratory due to the crowded classroom, time lack and the weak laboratories readiness. I let few students participate if experiment is performed in the laboratory." (PP.M.35.12)

This teacher came up with a creative solution to deal with the lack of resources:

"We do an experiment once per week, either in the class or in the lab. Students are very curious to see experiments. I am used to use cheap and available material, if we don't have proper materials. I believe the value of implementation, and students' curiosity. But I want to complain about the lack of chemical materials, hence I practice my teaching hobbies by using home materials experiments outside laboratory chemicals frame." (P.F.25.6)

Others stated that the amount of time that was devoted to science class was not enough to be able to plan and perform an experimental demonstration with the students:

"We have a lab, but not enough time to prepare the experiments or to fix some instruments. If we have lab keeper it would be easier to perform experiments. Laboratory is equipped but everything

thing should be cleaned and organized by lab keeper whose absent and if I want to do so, it will consume so much time.” (P.M.25.2)

“It is difficult to perform experiments based on the fact that we lack materials in addition to shortage in time, for we have just two classes of chemistry per week.” (PP.M.32.8)

Teachers try to compensate for the lack of lab time by the integration of ICT:

“We show them some experiments on the Internet. My lab usage is very limited as I have allergy and tend to use the experiments that are safe for me. Time is not enough to perform experiments (condensed textbooks). Our labs are not ready for students’ usage. I tends to demonstrate using videos displaying more than hand works in laboratory justifying that due to personal reasons (having allergy) and pedagogical reasons, like lack of time, condensed text books and the weak laboratories readiness.” (P.F.38.15)

If laboratories are being used, it is as rarely as approximately three times per semester and has further reduced due to laboratories going out of service as a result of the civil war:

“I am using the lab, and we have performed many experiments as demonstration. Now, (after crisis) we don’t have chemicals tools to perform all experiments. Safety issues mentioned when needed, for example: we are using acid in this experiment so I will mention the safety issue for acid usage. Currently the matter is restricted due to the crisis and its circumstances, moreover that there is more pedagogical issues that are preventing lab usage like excluding experimental exam questions, and the non-specialist lap keeper.” (P.F.57.28)

However, some teachers say that they had problems before the crisis as well:

“Even before crises our labs were not active as we have prepared labs with new instruments that are not prepared to work. Our lab keeper are not qualified to prepare labs. Chemistry materials are not well prepared. We lack time to cover the lab activities. The situation is the same whether before crisis or after the crisis. Obstacles to use laboratory are integrated within pedagogical frame, starting from using school as refugees’ centre, type of laboratory equipment serves physics rather than chemistry, time lack, poor teachers’ experiences, crowded class room and non-professional lab-keeper.” (P.M.54.25)

Three out of eight male teachers and four out of ten female teachers are including laboratory work in chemistry and physics courses currently. None of the teachers between the ages of 20 to 30 use laboratories. Six out of eleven teachers aged between 30 to 40 years and one teacher out of two aged between 40 to 50 years old employ practical laboratory work:

“We have active labs, and we are introducing lab safety through the experiment. The teacher and the students are participating in experiment like holding test tube. Some experiment can be done by students (simple one). Experiments are video recorded in order to be to be distributed among other teachers to help trainee science teachers. Our criteria are in international standards and modern style mainly depends on students’ research qualification and participation. Integrating safety rules within experimental laboratories are also essential.” (PP.M.36.12)

“I prefer having my class at lab, or bring some materials (test tube, beaker, chemical) to class to increase students’ curiosity. Once in a semester experiment are held in the lab. The most interesting experiment is the one that has colour, sound, and light. Some students may help to carry test tube, take a reading for instrument. Sometimes different groups perform different

experiments at the same time. I also try to attend all the ministry workshops, and neighbouring countries' workshops. I indicate the availability of rich school laboratories with high initial cost but there is no enough places for all students." (P.F.36.13)

None of the teachers above the age of 50 used laboratories. Where experience is concerned one out of three teachers with less than eight years' of experience, five out of nine teachers between eight to 15 years of experience and only one out of six teachers with more than 15 years of experience were using laboratories before the outbreak of war in Syria:

"Lab work is performed by students, and I supervise them. Yes, I mention safety issues based on the experiment, e.g., safe usage of acids. I am using lab as demonstration (before the crisis), now it is difficult. The ministry is making enhancement by establishing regular workshops. In addition, student's ability and curiosity must be in harmony with the experimental environment especially coloured and sounded experiments but currently the situation has changed." (P.F.35.12)

Two out of ten public school teachers use laboratories in chemistry and physics education regularly and five out of the eight teachers that are working both in governmental and non-governmental schools used laboratories before the civil war.

Exemplary teachers' quotes with positive and negative attitude of using practical work are:

"I partially use laboratory, if we want to activate the lab usage, we have to change the curriculum and number of students in class should be decreased. I used to demonstrate experiments in the class not in the lab. Students are interested in any experiment that contains change (colour, sound). Teachers normally hesitate to use the laboratory because they lack experiences." (PP.M.35.13)

"Lab work is used in our classes. We have workshops to teach to get benefit via teaching in different instruments. We are not able to perform experiment in the meantime because of time and chemical material shortage. We mentioned safety issues before the experiment. Students don't take working in laboratories seriously feeling that they are only having fun, even hand works is really fruitful." (PP.F.30.6)

"Yes, I am using the lab, if all materials are available." (PP.M.30.8)

"Our labs are not ready to accept students, there are no enough chairs and tables. I usually bring materials to class for experiments. During the 1st semesters we couldn't use the lab. I wish having modernity in the laboratory either via equipment or students' distribution and behaviour." (PP.M.34.11)

The third item that has been investigated in the frame of this study is the teachers' use of the history of science in teaching. 13 out of 18 teachers interviewed support the idea of including the history of science in their classes:

"I used to motivate the students for the discovery of ideas. I am interested in engaging history of chemistry within class studies using pedagogical concepts and focusing on how the idea was born, or how historical genius people start thinking." (PP.M.35.13)

Often finding creative ways to introduce the subject to their classes:

"Historical characters are discussed in my classes, in addition to new famous scientist. Many times I mentioned funny events happened with scientists to attract students' attention. Spotting light on scientists from modern era." (PP.M.32.8)

However, the teachers claim that the lack of time and the overload in the curriculum prevents them from delivering any extra materials. The other teachers raised concern that historical information is not well received and is considered uninteresting and irrelevant by the students due to its tedious nature and also because it is not tested in examinations:

"Historical scientists enrich the content. However, students are not interested in this type of information because it won't be in the final exam. I am admitting the importance of historical figures but this will not be completely active unless students are being asked about them in the exam." (P.F.58.30)

While some do ask students to mention it:

"*I don't use it a lot, but I am asking the students to refer to it."* (P.F.25.6)

But, the lack of interest from the students is something that more than one of the teachers interviewed mentioned:

"Scientists are mentioned to focus on their achievements in different scientific fields, like Jaber Bin Hayan. I don't mind indicating such issues relating to history of science, focusing on Arabic and Islamic scientists achievements but in general students will not take care." (P.F.42.17)

In total seven male out of eight male teachers and six out of ten female teachers include history of science in their course structure. One out of two teachers aged between 20 and 30 years old, Seven out of the eleven teachers aged between 30 to 40 years old, two teachers between 40 and 50 years of age and all three over-50s inculcate history topics in chemistry and physics:

"Historical characters should be used to show the students the efforts of scientists. I am enthusiastic to let students getting benefit and entertainment simultaneously, by celebrating a Chemistry Day. I mention mysterious concepts which had induced scientists' curiosity in the history." (P.F.36.13)

Again, where experience is concerned, two out of three teachers with less than eight years of experience, seven out of nine teachers with experience of eight to 15 years, five out of six teachers with more than 15 years of experience are including the history of science:

"We are always mentioning Arabic scientists and link their achievements with our topic. I insist on merging history of science within the lessons." (P.F.57.28)

Six out of ten public school teachers are including science history while seven out of eight teachers who work in both governmental and non-governmental schools are open to use the history of science in their classes. The United Nations schools are one of the best examples:

"I ask students to make very simple research to show the work and performance of historical scientists. It is obligated by the United Nation system to put history of science within the pedagogical frame plan." (PP.M.36.12)

"We mention different historical characters and their experiments. But I am not enthusiastic to that type of activities." (P.F.42.18)

"We give brief information about scientist achievements. I am slightly using the history of science and historical figure especially in formal grade, I also try creating curiosity or some interesting stories to attract students' attention." (PP.F.30.6)

"Yes, I asked students to read it. I am not reluctant to use history of science within teaching process." (PP.M.30.8)

"I am focusing on historical scientists, like Rutherford Dalton, and their scientific experimental improvements. We mentioned the historical scientists, like Mendeleev, and his role in finding the periodic table. I am aware of history of science importance, focusing on specific type of demonstration to catch students' attention." (PP.M.34.11)

"I can mention the scientist work within two minutes, as the textbooks are much overloaded. But in all cases I am slightly interested in history of science and scientists achievements in several fields." (P.M.25.2)

"We mentioned the scientist achievements, not his life." (P.F.38.15)

"I don't mention history of science as they mentioned in book as extra reading. Due to other priorities and responsibilities that he should perform." (PP.M.35.12)

"Historical characters are mentioned with their works, but not all teachers know about these scientists. I considers history of science as a cultural issue more than pedagogical tactics, talking about such culture briefly." (P.M.54.25)

When asked about their views on the curriculum, only five out of 18 teachers expressed satisfaction and had a positive opinion about it:

"I am satisfied with the new curriculum due to the English symbols which enable students facing university curriculum without so many challenges in addition to the curriculum technical materials like images and topics' order. " (P.F.42.18)

Others are generally pleased but notice some aspects in which it is lacking such as the arrangements of the topics within the textbooks:

"The tenth-grade chemistry book is good, but we need to better connect between 10, 11, and 12th grades and make it broader." (P.F.33.8)

"The new curriculum is good, but the arrangement of the units is not strongly linked to the units in 11th and 12^{t}. Books are clear with good pictures and less mistakes. I didn't participate in developing the new textbooks. The new textbook intend to increase the student role." (PP.M.35.12)

Despite the fact that some teachers thought that the new curriculum was not time effective, others had the opposite impression:

"The new books are better as they lack repetition and they are shorter so we have time to complete them. We have a lot of questions like filling in the blank, choose, and match. These questions are the favourite type for most of students." (P.F.57.28)

Most teachers complained about the complexity of the new curriculum, the incompatibility of the grading system, and a narrow focus on theoretical knowledge only:

"I deleted some materials as they are very hard or because, they didn't cover previous knowledge base. Our curriculum is excellent, but lacks the applied part. Very condensed textbooks. "(PP.M.35.13)

Students really have to work hard to be able to succeed in the context of the new grading system:

"*The new curriculum is very intense, not revised or tested, yet with a lot of concepts. Students have to master the materials that would help them to get high grades in final exam.*" (P.F.36.12)

Some teachers find the new curriculum incompatible with the teaching time:

"The textbooks are very huge, but we lack time to complete the book. However they are good and covers many aspects. New curriculum difficult, as our old textbooks were much easier in the flow of materials, and the connection between the grades. At the beginning of the year we have 3 days workshop regarding the new textbooks." (P.M.54.25)

Other teachers consider differences by the new curriculum because they feel that it encourages more student interaction with the curriculum. Teachers admitted that the level of the new curriculum does not accommodate with the ability level of the students due to its complexity and low achievement level among a majority of students, especially in mathematics which prevent students from understanding physics and chemistry:

"We find a gap in the mathematical equations since it is in higher scientific level than students' level. We suffer from high scientific level of the new curriculum which prevents students from understanding specific issues in mathematical equations. "(P.F.35.12)

However, it could also be that the challenges of this new curriculum brought out the underlying problems that students have with their mathematical and scientific base knowledge:

"Teacher centred classes, and our students would like the teachers to summarize the content of the curriculum. Students care more about the mark, so they are not creative in answering questions. We have to turn students into creative and active students, by enhancing and supporting their activities. Our students have a weak base in science and math. "(P.F.58.30)

In gender comparison, only two out of eight male teachers and three out of ten female teachers gave a positive rating to the current curriculum and considered it as being appropriate for the class. None of the two teachers aged between 20 to 30 years old, three out of eleven between the age of 30 to 40 years old, one out of the two teachers between the ages of 40 and 50, and only one out of three teachers older than 50 years old had a positive view of the curriculum. In relation to the experience, three teachers out of nine with experience of between eight to 15 years, and two out of six teachers with more than 15 years of experience liked the curriculum, whereas none of the three teachers under eight years of experience had a positive opinion. Concerning the school sector, three out of ten public school teachers rated the curriculum positively whereas only two out of eight teachers who are a part of both governmental and independent school sectors appreciate the curriculum. However, most of the teachers see an improvement by the implementation of the most recent textbooks:

"The new curriculum is excellent, but sometimes I find weaknesses in some locations whereupon I support the students with extra exercises and extra explaining. " (PP.M.36.12)

Teachers feel that the new curriculum also better prepares students for higher education:

"The new curriculum is better than the old one, for it has better images and English symbols which fits university degree studies." (P.F.42.18)

"I am satisfied with the new curriculum due to the English symbols which enable students facing university curriculum without so many challenges in addition to the curriculum technical materials like images and topics' order." (P.F.42.18)

"The new curriculum still has intense content, but with addition of images and more questions." (PP.F.30.6)

"The textbooks are very tense and school time is not enough to cover it, so we tend to ignore some topics that won't be needed in the following years 11th and 12th" (P.M.25.2)

"The new textbooks are much better than the previous ones. They have more examples, more diverse topics. If we want to improve textbooks: we need to simplify the information, and add even more examples." (P.F.38.15)

"The new textbooks contain good pictures, but they are more condensed and students are asked to memorize not understand." (P.F.38.15)

The following tables 2 and 3 summarize the findings according to teachers' feedback.

Table 2.Overview on the findings

Items	**ICT**	**Practical work**	**History of Science**	**Curriculum**
Positive views and practical application	13	7	14	5

Table 3. Positive views according to gender, age, experience and educational sector

Sample			**Findings**			
Characteristic		**Teachers number**	**ICT**	**Lab**	**Hos**	**curricular**
Gender	Male	8	7	3	7	2
	Female	10	6	4	7	3
Age	20-30	2	1	0	1	0
	30-40	11	11	6	7	3
	40-50	2	1	1	2	1
	50 <	3	0	0	3	1
Experience	<8	3	2	1	2	0
	8-15	9	9	5	7	3
	15<	6	1	1	5	2
Sector	Governmental only	10	5	2	6	3
	Governmental& others	8	8	5	7	2

A majority of teachers generally support using ICT in chemistry and physics education (see also Stylianidou, Boohan & Ogborn, 2005), independent of external obstacles, like unavailable Internet services or lack of electricity caused by the civil war. It is used in the form of visual aids by displaying instructional videos of chemical experiments on projectors or laptops. These teachers encourage students to access information on the Internet through curriculum related websites, using PowerPoint presentations, or school magazine publications. When compared to public schools, the schools set up by the United Nations are more efficiently implementing ICT in their curriculum by keeping the technologies and software up to date. According to Edwards (2013), the United Nation schools facilitate teachers with an online portfolio where the teachers can access the annual performances of students and personal growth. It includes the plan of the year and research made by students using the Internet which is an important part to be previewed at the end of the year. The case of ICT usage in the United Nations schools is similar to Jordan that addresses the distribution of ICT for both pedagogical and administrative purposes, focusing on cost efficient measures to acquire resources rather than solely relying on increase to the education budget (UNESCO, 2011). However the teachers working in the private sector in Syria in United Nations Schools mention that while they do have portfolios like Edwards mentions in his study these portfolios are not online ones. This means that not everyone can access them and benefit from the various feedback included in this valuable resource.

During the course of this investigation it became obvious that the Ministry of Education in Syria encourages teachers to use ICT in class by distributing instructional CDs and conducting various seminars and workshops to get the ICDL (The International Computer Driver's License), like in neighbouring countries as Jordan (Alhawari & Audeh, 2008; Jordan Ministry of Education, 2010). Despite that, some teachers prefer the conventional method of teaching on a chalk board with either demonstration-discussion activities or small phases of interactivity using tasks and worksheets, and justify their preference due to lack of resources in war time. Internet searches are also considered to be difficult now since power cuts and internet signal problems are frequent because of the civil war.

Some teachers try to solve the problem by storing information from the Internet on USB sticks and distributing them among the students. This approach has not been implemented thoroughly because of the absence of formal support for activities concerning ICT, and final assessment is still focussing on theory only without any regard for formative assessment or taking other content and skills into account (Bell & Cowie, 2011). Many schools in Syria were equipped with technological laboratories and students were frequently taken to these labs by some of the teachers. The students were divided into groups where they shared an apparatus, searched for the required topics and then several sub-topics were introduced within lessons to be inquired, discussed and exchanged. A teacher described this method as 'world link method'; it is similar to the learning model of practice communities where teachers and students negotiate epistemic agency and learn science as a practice (Stroupe, 2014). This activity has mostly been suspended and discontinued due to the detrimental effects of the civil war on the infrastructure. In addition to that, most schools have been turned into refugee accommodation centres therefore increasing the number of students in each class of the schools that remain in service. Laboratory access in Syrian schools is also impeded due to situations created by the civil war that prevent them from conducting any extra activities outside the classroom.

Since classrooms are crowded and equipment is not in sufficient supply for all the pupils to use, most students end up as only passive observers of experiments taking place in labs, rather than performing them themselves, if experiments are done at all. If teachers still do experiments, due to facility limitations, the teachers bring the lab equipment into class themselves, which is not in line with either safety regulations or the boundaries of consent of some parents. Safety procedures are rarely followed to the letter when doing the experiments in the classroom as one of the teachers mentioned the necessity of displaying pictures to students which are posted on chemical bottles to let them understand each material safety issues. Some of the few active teachers insist on performing experiments despite all the aforementioned difficulties. They employ simple materials from the kitchen to demonstrate a chemical reaction like using lemon and baking powder or cabbage leaves as indicator. They encourage students to perform experiments at home and to fully comprehend the given information instead of just plain memorization of theory.

In contrast to public schools, private or non-governmental schools make it obligatory for the teachers to include laboratory work in their class curriculum, yet due to inefficient and undertrained lab technicians the advantages of laboratories cannot be fully utilized. Teachers are not trained to formally set up equipment in the lab and cannot juggle between arranging laboratory environment while simultaneously preparing for classes. In general, chemistry teachers' experimental performance is not at the required level. This is not uncommon in Arab World countries, as it has been described in, for instance, Jordan, where the acquisition of highly-qualified teachers in chemistry looks to be unachievable (Al-Doulat & Abu Hola, 2009). It has been acclaimed that science teacher education programs should be developed and improved, as suggested for other Arab countries (Al-Amoush et al., 2012). One reason for the low success-rate of the teacher training might be that teachers were prepared to become a scientist first and a chemistry or physics teacher only secondarily. It is not clear whether all of those at university level choosing to become a teacher later are doing so because of an intrinsic motivation, or because they fail to get a job as a chemist or physicist. Nevertheless, in both cases there is a lack of preparation in the field of their later occupation. To achieve a radical change in beliefs and in teaching styles, to be able to integrate modern theories of learning into current teaching tradition, it is not enough simply to attend a series of short workshops. Instead, it would be much more beneficial to have teachers attend workshops continuously throughout their teaching careers (Oliamat, 2009; Al-Amoush et al., 2011).

Most teachers support the ideas of including aspects of the history of science but most of them simply mention the most famous scientists and their achievements without connecting the information to general developments of history or society. Some mention Arabic or Islamic scientists to reinforce students' national Islamic spirits. This limited model doesn't provide a mechanism for exceeding the mindless devotion of science education to transmitting knowledge of the "final-form" products of the context of epistemological justification. If the education of historical thinking is to have any worth, students will develop awareness that there are often parallels between their thought and earlier scientific thoughts. This will only be realised if an appropriate opportunity has been provided for students to clarify their own understanding and interpretation of the phenomenon in question. Hence, this phase is an essential component of the proposed model of pedagogy (Monk & Osborne, 1997). Very few teachers mentioned that they teach the history of science as a story to make the lesson more interesting, presenting for example, how the idea of the periodic table of the elements emerged in history, reminding us that the role of the scientist is not just to discover the "facts of science" but also to construct them trough the use of creative imagination (Sutton, 1996). Once again, the teachers blame time constraints and heavy curriculum overload as reasons why they cannot digress into teaching material that will not be tested in the final examination. The findings show that the majority of teachers support the history of science even if they do not really adopt it effectively.

The findings show that teachers hold an overwhelmingly negative opinion towards the intended curriculum stating it as complex, too heavy and preventing them from accomplishing any other activities such as integrating ICT, using the laboratory, or developing an understanding of the history of science. However, many also describe progress by recently implemented textbooks. Anyhow, according to some teachers, the practical section of the textbooks has insufficient information and is not compatible with the theoretical parts. Some teachers complained that they find no improvements in the new curricula and no significant differences from the previous curricula. The current textbooks try to set a new vision towards the teaching of chemistry and physics with its visually aesthetic and pleasant outlook, inclusion of more activities, less mistakes in the content and more English symbols. However, for some teachers this improvement is still unsatisfactory when it comes to a student-active pedagogy. Many teachers lament the incoherent gaps in the syllabus and the illogical order of the topics. For example, the topic of organic chemistry should be taught at the beginning of the academic year due to its time consuming nature but it appears at the very end of the text book. The logic of organic chemistry needs more time to be imprinted into students’ cognition as one of the teachers declared. Other teachers admit that the level of the new curriculum neither fits the attainment levels of the students nor the curriculum of consecutive grades. Therefore, some teachers have started to reduce or skip content from the curriculum that is not essential for the further grades. Syrian teachers’ views about curriculum are not so far from a similar study which was carried out in Jordan, where chemistry books are described as being unable to make connections among the different topics and between different levels of understanding (Al-Amoush et al., 2012). However, there were also some positive comments about improvements, images, and colourful illustrations as they increase recognition. More activities and types of problems have been suggested for the new curriculum to improve student-oriented teaching and learning, promote students’ performance and transform them into active learners. But, as previously stated, this is not sufficient for the majority of the teachers. More research on beliefs and knowledge is needed for curriculum visionaries and developers, who can more successfully perform curriculum changes by taking current teachers□beliefs and prior knowledge into consideration (De Jong et al., 2002; Eilks et al., 2006; Justi et al., 2006).

To sum up, teachers from this sample can be divided into two groups. The teachers of the first group are dynamic and open to modernity and reform. They want to use ICT and the laboratory even in times of civil war. They appreciate the implementation of the history of science in lessons, although even these teachers do not utilize its full potential. Common characteristics of these teachers are defined by their age in the range between 30 and 40 years old, having between 8 and 15 years of experience, and they work simultaneously in governmental and non-governmental schools. The reason behind the first group being active and more open is due their youth, as well as having enough experience to reflect on and improve their performance. More open experiences are generally made in the non-governmental schools where the infrastructure is better and salaries are higher than in the governmental sector. Teachers who are working in the non-governmental sector are better prepared using a similar style also in the governmental school teaching. The other group includes teachers that are very sceptic about their practices, inactive and reluctant to reform. These are the quite young teachers and quite old teachers. All of them only teach at governmental schools and lack experience in the non-governmental school sector.

Table 4. Classification of interviewed teachers

Group 1: Dynamic teachers	Group 2: Sceptic teachers
Age in the range between 30 and 40 years old	Older than 50 or younger than 30.
Having between 8 and 15 years of experience	Very experienced with more than 15 years or less than 8 years.
Work simultaneously in governmental and non-governmental school	Only teach at governmental schools

Conclusions and implications

This case study examined teachers' professional views on secondary school chemistry and physics education in Syria. The teachers have been interviewed about their view in dealing with four aspects of their teaching practices, namely the use of ICT, practical work, the history of science, and teachers' perception of the curriculum which has been recently changed. According to the findings, more than half of Syrian teachers use ICT and are in favor of the history of science, although they are not able to operate both thoroughly. Less than half of teachers use the laboratory and do so in a very restricted manner. Most teachers are very critical towards the intended curriculum. At the moment there is no opportunity for the curriculum to be adjusted, since even qualified teachers are struggling to deal with the overcrowded classes caused by the current crisis. In such circumstances teachers try their best to focus on making sure that all of their students are able to pass their examinations. The teachers cite many other limiting factors for their practices as well. Some of these are time constraints and the overloaded curriculum, in spite of the Curriculum and Evaluation Department in the Ministry of Education specifically concerned with curriculum development, adaptation, and evaluation. But there is still a lot to be done to reinforce these experiences at the senior secondary school level. The situation has worsened even by way of a growing crisis in infrastructure since the start of the civil war.

Overall, investment is needed in re-establishing better working conditions for chemistry and physics teachers in Syria after the civil war will be over. However, there is also investment needed to bridge the gap between governmental and non-governmental schools (NCES, 1997). Long-term continuous professional development is needed to make teachers who often fight with passing culturally responsive pedagogies (Brown & Crippen, 2017) familiar with and experienced in better utilizing ICT, practical work and related tools in science education to become more versdatile and goals-oriented so that they can activate students and promote cooperation. But, also curriculum reform is needed to better adapt the curriculum to the students' capabilities and needs, in terms of better incorporate student-relevant contexts, the nature of science, and to align the curricula for the different grade levels.

Chapter 4: The experienced curriculum and pedagogy: An interview study with twenty-six secondary level school students in Syria

The experienced curriculum and pedagogy: An interview study with twenty-six secondary level school students in Syria

This study evaluates secondary students' perception of their science classes. The study used semi-structured interviews with 26 Syrian students (age range 14-16) from 12 secondary schools in Damascus, the capital of the Syrian Arab Republic. The first focus in the interviews was the students' perception of the science learning environments in Syrian schools. The second focus dealt with students' interest and motivation in science subjects. This part aimed to investigate the participants' opinions on the inclusion of science in practical situations and as a part of their daily lives, while the third part of the interviews focused students' perspectives on being interested in embarking on a career in the various branches of science. The analysis of the interviews revealed the dominance of teacher-centered pedagogy and a pure focus on theoretical content knowledge learning in science classes in Syria. Group activities appear only in the form of competitions among students. The reliance of the teachers on the textbooks is high despite their complex nature. Students face challenges in their coursework due to flawed teaching methodologies, and damaged infrastructure due to the civil war. Assistance is sought from family members or private tutors. Chemistry dominates as the students' favorite branch of science, outside school activities are mostly performed at home. From the students' utterances, parents hold a positive attitude towards high achievement of students in the sciences. Students are predominantly predisposed to careers in medicine and engineering whereas purely academic careers in subjects like math, physics and chemistry etc. are rarely favored as a profession for the future.

Introduction

In order to prepare Syrian students to be well trained and competent in a more internationalized and competitive world, it is crucial for Syria to re-establish educational infrastructure that is competitive with international standards. It seems to be unavoidable to invest in science and technology education at an earlier stage and throughout all schooling levels. It is important that pupils are familiarized with basic scientific concepts but also with skills for decision making, problem solving and critical thinking. Hence, there should be an inclusion of innovative content and pedagogy for promoting conceptual understanding via the teachers to support the learning process for students (Fenstermacher & Soltis, 1986). However, the literature says that traditional methods of teaching in Arab countries revolve around lengthy, content-focused lessons delivered by the teachers with little to no contribution or involvement of the students in class (Al-Amoush et al., 2012). This is not uncommon in Arab countries where classroom management is based on maintaining order and achievement in theoretical content learning (Alshoraty, 2014). In a study conducted in Jordan by Al-Amoush et al. (2012), the teaching and learning conditions were compared between Jordan, Turkey and Germany. The study showed that Turkey and Jordan have dominant teacher-centered styles of education and a strong focus on pure content learning, unlike Germany where student-centeredness is intended. Appy and Appy (2007) expressed that currently employed teachers should understand that this method is not in line with modern and current educational standards. Lederman (2009) suggested that new techniques in teaching should be introduced such as scientific inquiry that leads to improvements in science learning, thinking skills and understanding of the scientific methods among the students (Lederman, 2009).

Syria, alongside other Arab countries, requires science teachers to have a strong academic background and be highly experienced in laboratory work (Elliott, Stewart & Lebowski, 2008). However, even if teachers are well-prepared, the educational sector in Syria generally fails to provide basic facilities like access to Internet, ICT and science laboratories in schools. Lederman (2009) suggests that additional activities such as field research could be performed by the students outside of school to compensate for the absence of these provisions. However, this is difficult in times of limited resources and other limitations caused by the civil war.

It is highly important that revisions in the school curriculum and pedagogy are made which are in accordance with the current social and environmental conditions of the learning environment as done in current Egyptian or Saudi Arabian chemistry textbooks, which approximately meet the required criteria for modern science education (Khaddoor et al., 2017). For that purpose, it is necessary that the students' perspective is taken into account regarding their daily life necessities in social and environmental settings and the difficulties they face in the current war circumstances (Badran, 1993). When students are faced with sub-standard textbooks and teachers focusing on theory-based textbook memorization, alongside limited access to ICT and laboratory facilities, they might start looking for external aid for achievement, but this might not be available for all students. It might also be the case that students lose motivation and start to abstain from science learning.

Information regarding students' perception of science learning and preferences in science topics is rare in the Arab world in general, and for Syria in particular. It will be helpful to know what topics and skills from the field of science education are most popular among Syrian students. Such knowledge will help to better understand what the students would like to learn, what would motivate them to learn science and how they learn, starting from their previous knowledge to bridge the ideas to the subject matter presented by the teacher (Bransford, Brown & Cocking 2000). Also, in the collectivist Arab culture, parents often influence the career paths of their children. Nevertheless, it is crucial that the student is well informed about his career chances, if it is in the field of science, to discuss with, and when necessary, question, their parents' decisions.

In this study, 26 10th grade Syrian students were interviewed and asked about their perception of learning science, both inside and outside formal classroom environments. The study focusses on students' motivation and interest in science and seeks the students' views on whether they wish to embark on careers in science and engineering.

Theoretical framework

School education is a social act that is based in the interaction and communication between teachers and students, as well as among the students themselves. Stacy Olitsky (2007), for instance, discussed the importance of interaction rituals in class that are characterized by elevating the attentiveness to the content, promoting energy, reinforcing collaboration, developing solidarity among students, and highlighting self-esteem. In addition to that, constructivism and inquiry-based teaching are suggested to encourage students to have an essential role in learning because of the high interaction of the students in class (Bodner, 1986; Hofstein, Abrahams & Kipnis, 2013). Inquiry activities encourage the students to share and discuss their ideas and be proactive in searching for scientific knowledge (Wallace & Kang, 2004).

Although the activities of students are central for learning in class, the vital role played by the teachers in the educational sphere should not be disregarded (Markic, Mamlok-Naaman, Hugerat, Hofstein, Dkeidek, Kortam, & Eilks, 2016). A perfect class needs highly qualified teachers that are well versed in up-to-date pedagogical methodologies and are supplied with adequate resources and materials in order to meet the needs of the students (Boujaoude, Ayoubi & Jaber, 2008). Unfortunately, most formal educational practices in Arab countries still believe in a teacher-centered approach albeit all its negative aspects. E.g., Al-Amoush et al. (2012) present Jordan as an example of this approach in their research on chemistry education practices. The traditional way of teaching follows the idea that the teacher transmits her or his theoretical knowledge to students without involving them in effective discussions or practical activities. Based on this study, 87% of the Jordanian chemistry teachers follow the traditional method of teaching, although they believe in the positive effects of modern pedagogies.

ICT is a boundless source of knowledge and, when included in science teaching, it can provide a vast pool of information benefiting the learning abilities of the students (Bingimlas, 2009). Teachers can utilize ICT to engage students with assignments that require them to access information through educational software and the Internet, which would not only add to their understanding but also make them more efficient in their researching skills (Dori, Rodrigues & Schanze, 2013). Lavonen (2008) suggests that this technique has the potential to enrich students' knowledge due to the unlimited number of online references available and stimulates them to have effective discussions with each other and with their teachers. It also enables the students to learn independently without being guided by the teacher at every step. This, in turn, raises the self-esteem of the students and their responsibility toward knowledge (Bingimlas, 2007). Indeed, students can also benefit immensely from supportive educational class activities such as group work and class discussions (Lazarowitz, Prins & Eilks, 2013). Students can be asked to work on a group project alongside their classmates, where the tasks are divided amongst group members and the outcome is presented in class in the form of a report or presentation. This gets the students involved in a number of productive activities, like searching the web, preparing PowerPoint presentations, polishing their oral presentation skills and coordinating with other group members (Lavonen et al., 2009).

Textbooks are another essential element in the educational system. Textbooks represent the intended curriculum and suggest the style of teaching (Devetak et al., 2013). Textbooks are relied upon by teachers and students alike in Arab countries as the main source of information required by the curriculum, and teachers are obliged to teach from the official textbook (Farag, 2006). It is extremely important not only that the composition of textbooks ensures delivering accurate and reliable information but also that corresponding information is contextualized and its use is student-centered (Bodner, 1986; Binns, 2013). The content of the text must be in line with the cognition and understanding levels of the students according to their class ranking, and complex information and ambiguous terminologies should be avoided (Slough et al., 2009). Textbooks should also be illustrated to open the door to science for the student. A study by Devetak and Vogrinc (2013) found that visuals included in the textbooks can increase the interest of students and assists them in understanding the content of the text more easily. Therefore, graphics and illustrations must be given importance alongside the comprehensibility of the text to get the maximum learning potential out of textbooks' usage.

Learning is only relevant to the lives of the students when the knowledge acquired from the classrooms can be transferred and applied in everyday life, societal or professional situations (Stuckey et al., 2013). One of the main purposes of science education is to prepare the students to practically apply scientific knowledge outside of classroom and laboratory settings. Van Berkel (2005) discussed how acquired scientific concepts can be transferred to general situations outside school. To achieve that, teachers should encourage students to find and observe simple chemical reactions, like rusting and corrosion of metals, and try to explain the process using scientific explanations but starting from real-life contexts (Greeno, 1998).

The complexity involved in the study of science can be a reason for the lack of interest among students. However, additional factors also come in play that could incline the students towards liking or disliking the field of science, like the inclusion of topics of interest and relevance to them (Stolz, Witteck, Marks & Eilks, 2013) and learning material that would be useful in practical life for achieving a high degree of perceived relevance (Stuckey et al., 2013). Generally, students prefer topics that coincide with their interests and background, for example the biology course as it discusses nature, animals, plants and space and it also helps them to understand their bodies and health (Dagher et al., 2011). Any integration of practical work in science courses can also raise students' interests and enthusiasm in the subject (Oliver-Hoyo, 2011; Hofstein, Kipnis & Abrahams, 2013). Altogether, topics taught in science classes should integrate aspects of daily life and practical work in relation to scientific phenomena to increase knowledge and maintain interest and motivation (Bolte, Streller & Hofstein, 2013). Indeed, education is not just a tool for imparting knowledge but should raise awareness among the students that will help them choose their future careers, based on their interests in school (Osborne, 2003).

The purpose of this study is to access the views of Syrian students regarding their science lessons, the teaching-learning methodology, and both teacher and student roles. Furthermore, the interest of students in science subjects within the school environment and outside class is put into focus by inquiring into students' views on a potential career in science or engineering fields.

The research questions in this case study are:

- *How do secondary school students in Syria perceive their science lessons in term of the curriculum, the pedagogy and any interactions in the classroom? What are the main problems that students face in learning science and how do they try to solve them? What are the noticed changes in learning science within the last few years?*
- *What interest do the students have in science? Do they realize the importance of science in daily life? How does science learning in school relate to any interest outside school and with the parents?*
- *What is the interest of the students' in future career in science and engineering and what are the reasons behind any interest or disinterest?*

Sample and method

Sample

The sample of this study are 26 science students currently enrolled in 10th grade education from 12 different secondary schools in Damascus, the capital of Syria. The students were aged between 14 to 16 years. These students were selected randomly on the level of achievement. The sample size was purposefully selected to achieve a good male to female as well as higher to lower achievers balance. All students participated on a voluntary base. The total sample size consists of 11 male and 15 female students,

Method

Data was collected using semi-structured interviews. The overall structure of the interview guide is presented in Table 1. Each of the three sections of the interviews was introduced via a leading question to be led further by several sub-questions.

The first section discussed science lessons with regard to the curriculum, the role of teachers and students in class and the structure of the lesson. It was aimed to identify whether there is involvement of group work, laboratory, ICT, and student-active class activities in the lessons. It also assessed how students are learning to face the challenges and solving problems in class and the changes regarding science learning.

The second section covered the interest of students in science and what generally motivates them to learn science. The students were asked about what they consider to be interesting when it comes to science classes and what are the reasons behind their preferences. Furthermore, they were also asked about their opinion about application of science in practical situations, their achievements outside of school, and their parents' attitude towards their achievements in science in class.

The third theme revolved around accessing students' attitudes towards science as a career option and the career choices they prefer. The students were also asked to provide reasons for their inclinations towards a particular career path.

Table 1. Overview of the interview guide

Topic	Questions and sub-questions
Science lesson	Please describe a typical classroom situation from your science lessons? What does teacher generally do? What do the students generally do? 1) How do you use ICT and the laboratory within learning and what are the obstacles which prevent using such facilities? 2) What are the types of extra activities used in the classroom to learn science? 3) How do you interact with other students to practice science? 4) How do you get benefit from the textbook? 5) What are the problems that you face while learning science and how do you try to solve your problem? Who supports you? 6) What changes occurred in the last few years?
Interest and motivation	Are you interested in science? If yes why, if not why? 1) What is your most interesting topic in science? 2) How do perceive the role of science in your daily life? 3) What science-related activities do you practice outside school boundary? 4) How do your parents look at your achievement in science?
Science careers	What are the most favorite career to you and why? 1) Is there any profession related to science and technology that attracts you, if yes why and if no why?

The interviews were conducted separately with each of the students by an Arabic native-speaker and lasted for, on average, approximately 30 minutes. All the interviews were audio-taped and then transcribed. Analysis was carried out following the principles of qualitative content analysis (Mayring, 2000). Data-tables were developed with the main section mentioned above. The answers from all the interviewed students have been inserted into the table using a deductive category development from the interview guide by two independent native-speakers of Arabic. Afterwards, the codes were grouped in a cyclical process into more general categories until at least 90% of the data material was operated into the relevant findings. Agreement rate in coding was high and constantly above 80%.

Findings and Discussion

Students' perception of the pedagogy and curriculum in science lessons in Syria

When students were asked about the pedagogy of their science lessons in Syrian schools, a general theme emerged. Many teachers intend to ensure a mostly quiet atmosphere with no interaction between the students and no interruptions from them. The classes regularly begin with the teacher examining the students concerning their knowledge gained in previous lessons. Generally, the teacher then continues with a new topic that starts by presenting the theoretical base of a given topic and consequently moving on to the more complex issues in the topic.

Most of the time, the lesson regularly is choreographed according to the structure of the topic as presented in the textbook. Often there is a very structured mix of lecturing the theory along with examples, then asking students for their comprehension in between. The theory is explained step-by-step by the teacher. Sometimes it is suggested that students abstain from asking questions to the teacher until the very end of the lecture. Before the lesson is over, the students are generally allowed to ask questions they have, regarding the lesson content. The analysis shows that only 5 out of 26 students mentioned that the lessons begin dissimilarly to this approach and start with an example from daily life and the practical implication of the content to be learned.

Exemplary quotes from students about the classroom learning environment:

"When the teacher comes into class, he orders to open the book and the notebook, for controlling the homework and write it on the board. Then he asks us about the last lesson. If the student didn't do his homework the teacher reduces his scores. He explained the lesson, then he gives us examples, then he cuts short the lesson. Finally he asked the students if they have understood the lesson to open the possibility for questions."

"He divides the lesson as paragraphs, and then he explains the content. After that he gives us the theoretical explanations with examples."

"Our teacher controls our homework and gives us question from the last lesson. She gives us lot of examples (fluids lesson). Chemistry: An example from the book and life then she explains the lesson and we write down the content in our notebook, She returns the information many time, and she asks us suddenly to make sure we have understood."

"First of all she asks us to keep silent then to open the books. She explains the lesson and gives us an example from the book (homogeneous body like water). Then she cuts short the lesson. She returns saying the information many time to make sure we understand."

"*The teacher makes sure we are doing our homework then we control it, Then she explains the lesson with an example, after that we write on our notebook."*

"Students rarely participate within the lesson demonstrations. We only participate in biology classes by posing questions of interest and ideas."

"If there is some interrupting from the students during the lesson demonstrations, our teachers says ask me in the end. There is no groups' activity, and there are just questions about the lesson on the board."

"Our teacher prefers us to understand more than memorization in many ways. He starts with introducing the lesson content. Some time he asks also the information from us."

"His styles depends on asking the students many questions in the beginning with examples from reality, we don't open the book. He divides the lesson into sections and gives us an example, then we write down a summary on our notebook."

"Her styles depend on examples from the reality, and she lets us memorizing lessons in the class room. She asked us to open the book and have a look in it. If any student doesn't understand any things, she makes her to solve with her hands on the board, the notebook is for solving the questions and problems."

When students were asked about their interaction with the curriculum, most of them stated that their lessons in science classes are purely based on the school textbooks and related workbooks with activities and to be filled by the students. The use of the textbook and related workbooks varies. Sometimes the books are central to the pedagogy in class, sometimes they are mainly used for homework. Nevertheless, the lessons are very much reliant on the textbook content. The students described a mismatch of their interests and the content in the textbook and how the content is presented to them. 17 students out of 26 mentioned that the textbook is the main source of information to them. 13 students out of 26 found the curriculum too difficult to study. To some students, difficulties with the curriculum even exceed difficulties with the operated teaching style. Only 4 students out of 26 found the teaching methodology caused more difficulties. So, although the textbook in Syria allows for contextualized learning at least to a certain extent (Khaddoor et al., 2017) the curriculum and pedagogy operated by most of the teachers follows a strong teacher-centered teaching methodology and structure-of the-discipline based curriculum orientation as described by Eilks et al. (2013).

Exemplary quotes from students about the curriculum:

"*We simultaneously use the textbook and workbook as a couple. We copy the content from the textbook and look up the rules from it."*

"We study physics from the notebook, chemistry from the textbook, biology from the textbook and notebook."

"We study from the notebook then from the textbook and use the notebook for more understanding and comprehension."

"We just use the textbook for the questions."

"We use the textbook just in home (personal effort) and we study from copybook. Other sources: Internet."

"We never use the textbook, just in homework. The further information in chemistry the textbook is important and the textbook is excellent and it depends on thoughtfulness. We are interested in the names of scientist in chemistry and science. There is a library but they don't use it"

"I suffer from the complex nature of any simple idea in the demonstrations from the teachers and his presentation in the textbook. The presentation purely depends on theory, and in the same time I am not able to do tutorials."

"I am unable to understand anything by myself from the textbook; I always feel that the teacher is necessary to understand such huge amount of theory."

"There is no logic relevance between the theory and demonstrated examples in the textbook."

The inclusion of collaborative and cooperative activities for reinforcing scientific knowledge is mainly limited to student competitions and a few class discussions. 8 out of 26 students mentioned inner-class competitions and group discussions as a part of the applied pedagogy whereas 16 out of 26 students mentioned that discussions among themselves only take place outside the classroom for resolving specific issues. Students themselves engage in informal discussions to help each other to understand the concepts taught in class or they hold controversial discussions. Such discussions in science can enhance the critical thinking skills of the students and broaden their intellectual capabilities although students avoid visibly discussing controversial topics because of fear of a negative reaction from conservative teachers. Furthermore, the teachers do not indulge in the discussion of such topics, which is justified by them on the grounds of shortage of class time and the dense curriculum.

Exemplary quotes from students about any cooperative aspects of the applied pedagogy:

"The curriculum and textbook is very difficult and there is no time to make any group works. We were using this learning style when we were in elementary stage, but now there is no way."

"I try to get help from better achieving classmates especially in mathematics problem."

"I discuss with my friends, who are qualified in mathematics, and I love studying and research works. I have the dream to understand that an earth has rotation axis, since everything all over the world has such an axis and if it moves the earth will move."

"I like to convince my friends with Darwin theory, but when the teacher is conservative I don't dare to open such discussions."

"I discuss some scientific problems with my classmates with equal achievement level until we reach the final solution."

When the students were asked about practical work in science lessons it was found that the inclusion of laboratory work is very rare. The amount and type of practical work, practical demonstrations and the use of digital resources is extremely variable and depends on the teachers teaching style. Mostly, teachers avoid taking their students to the laboratory. Instead, some of them bring the apparatus to the classroom and demonstrate small experiments like fermentation and rusting. Some students mentioned that experiments are conducted only in some classes but are not consistent and present in all the science subjects that regularly require laboratory work. 14 out of 26 students mentioned experimental demonstrations; the others did not even see demonstrations. Some teachers try to compensate a lack of laboratory work by utilizing ICT. Visual and figurative illustrations are displayed in the classrooms to explain which experiments are available and what they can show, and some teachers also use educational websites to broaden the view on science content. Educational videos are used to aid teachers in imparting experimental knowledge when laboratories are not operated. 6 out of 26 students mentioned the use of ICT in the classrooms to compensate a lack of practical work. Despite the availability of laboratories, required materials and laboratory staff, laboratories are rarely used in the Syrian schools, despite the fact that more satisfaction might be achieved with more hands-on activities instead of videos. The use of laboratories has decreased significantly as a result of the Syrian civil war. Students don't reach the level of required practical experience in order to attain expertise in the field that would enhance their daily lives.

Exemplary quotes from students about the practical work:

"We have never shown chemistry experiments because there are always changes in the chemistry teachers. But if it happens to come to practical activity, the teacher will use the projector and Internet to show us, using a laptop in the classroom."

"We have never done experiments. Before the war, we did but now the teachers are always changing. There is no integration of technology. In physics there was a little bit difference, the teacher took us to the laboratory and we did a few measurements regarding motion laws."

"We don't visit the laboratory but once upon, our teachers brought the three dimensional plastic pieces to demonstrate atomic structure."

"In general there is no experimental application in laboratories. But, I remember the experiment of brain anatomy, and using the sunflower leafs experiments staring from cabbage leafs."

"We rarely do experiments. Once in a year there is an experimental laboratory or technology laboratory. The teacher brings three dimensional figures to the classroom to use them in his demonstrations."

"In this year we have never visited a laboratory but in previous time, yes we were visiting laboratories for chemical reactions, and our teacher was leading the procedures of experiment"

"We have only twice visited a chemistry laboratory but in biology we do more practical work. We have been shown several videos about the atom, our teacher holds all wanted procedures, I remember from the last years we saw practical demonstrations about sponges and tree's parts."

"We did experiments when we were in grade 9. It was in the biology course, anatomy of frog and fish."

"We are doing many demonstration in biology rather than chemistry and physics, we like the biology teacher and her style. I am familiar with the experiments of potatoes fermentation, we have been shown a video about some type of plants like shame plants and Venus flytraps plants."

"We have been shown chemistry videos about arrangement of atoms, how many orbits there are in atoms, and about scientists."

"We were shown an example of shame plants via video, and Venus trap plants. We experienced potatoes fermentation. We have been shown anatomy of a dove and we have performed physical experiments in regard optical system."

"I remember from the last years that we practiced anatomy in the laboratory, e.g. dove anatomy and demonstration of digestive system. In chemistry, we have done a few reactions, e.g., lead burning, changing colors reactions."

"The physics teacher uses the screen and computers for demonstration, e.g., the straight movement – calculating speed, calculating time while a man running with specific speed and distance, motion types."

The students seek out assistance for school learning from non-formal sources such as educated family members, private tutors, and after-class private educational institutes. These sources are considered necessary to help the students with an advantage of one-to-one interaction and without time restrictions, unlike school classes. 13 out of 26 students professed taking help from their family members when facing difficulties in class, 1 in total is enrolled at a private institute and another 1 out of the 26 participants takes tutorials. In general, students prefer to reach out to their fellow classmates for help rather than to their teachers because of distance to the teachers, ease of comfort.

Exemplary quotes from students about non-formal assistance:

"The methodology of learning from the textbook or in classroom is very complicated. Hence, I feel forced to ask my sister for help."

"There are some lessons full of complications and deep difficulties. Therefore, I need the help from my father, and there is no possibility for tutorials."

"The ideas are not clear and the consequences of the ideas in the textbook are not logic to me. So, I always need the help of my brothers."

"The book is very interesting but I face misunderstandings in the concepts. There is general a direction towards memorizing word by word. For understanding, I need the help from my brother or parents."

"The chemistry is easy towards me. Our teacher is an expert and she knows how to approach the ideas. But, I suffer from physics and I always feel that I will not reach the meaningful goal even I if I fully read. Therefore, I ask for help from my brothers and sisters."

"Everything becomes easy by repeating against the curriculum difficulties. I get a help from my uncle."

"I like to study any type of science. But, I just need somebody to let me catch the string edge and then I will continue by myself. My mother sometime helps and I take tutorials"

"I find ease in chemistry. But sometimes it is complicated due to a few ideas like ionic compounds, charges, difficult problems. I rarely ask my brother to help me." "I don't feel myself that I fully understand the information but I don't get any outside help."

"The physics is very difficult, so much intersected ideas, like the ideas of relative and absolute changes. I don't take any help from any side."

"I don't get the help from parents. I only get it from friends and I attend an evening school. I understand things better there than in my normal school, since they exemplify scientific ideas using fingers, pencils, or any other simple tools"

When students were asked about the recent changes in their school life in the last few years, most of them focussed on two main points. The first point was about changes in the curriculum, the second was about the circumstances of the Syrian civil war. Despite the difficulty they ascribed to the textbook, students hold a positive attitude towards the new textbooks which - to them - is considered to be more interesting in comparison to the former ones. One student expressed that the textbook aids understanding of the topics instead of using it for pure content delivery, while another one uses the textbook only for assistance in homework. Another participant mentioned that he finds the textbook dull and boring. The Syrian crisis is affecting the learning abilities of students negatively due to a growing lack of infrastructure. This has also led to migration within Syria, tensions, overcrowded schools, lack of expert teachers due to migration out of Syria, political uncertainty, and economic decline. All the aforementioned factors impact negatively on learning ability. 8 students talked about changes in the curriculum, 5 students complained about the civil war circumstances, others saw difficulties in constantly changing teachers (see above).

Exemplary quotes from students about recent changes:

“The textbooks were very traditional before now. But, they became more attractive and they induce more to understand than just to memorize.”

“The curriculum is much more extended than before.”

“There is no change except psychologic pressure because of the war circumstances.”

“In this year we spent one month without teachers in one of the science subjects because of the war.”

Overall, the applied curriculum and pedagogy in Syrian science classes focus mainly on rote learning and memorization of theoretical content and dividing the lesson plan into several sections, whereby each is clarified at a time. Such techniques take students away from developing applicable knowledge, hinder communication between students, and might cause anxiety and learning difficulties (Mansour, 2015). Limited variety and student-centredness negatively affect the achievements of the pupils (Eilks, Prins & Lazarowitz, 2013). Therefore, it is likely that the number of low achieving students will remain stable or will even increase due to the limited effectiveness of the teachers (Mendro, 1998).

Interest in science and motivation

The second part of the interviews focused on students ‘attitudes towards science learning, the meaning of science for their lives, and any view on the practical application of scientific knowledge beyond the classroom learning environment. The students were asked about their individual involvement in activities related to science in their personal lives and the motivation behind it. They were asked to elaborate on the reasons for both the presence and absence of it.

14 out of 26 students were generally interested in science especially in science fiction and daily life science. 9 out of 26 mentioned their interest in chemistry describing that chemistry is applicable in daily life. Topics like the elements in the periodic table, chemical reactions etc. were mentioned by students as interesting in chemistry. 3 out of 26 students were also interested in physics giving gravity and physical interactions as the most popular topics in physics. 1 student out of 26 students claimed a special interest in mathematics while another two preferred biology.

Exemplary quotes from students about their interest in science:

“I like science since it depends on thinking and interest simultaneously.”

“I like science in general due to the possibility of linking knowledge but I hate the difficult expression in Arabic language. The general laws should be learned in English”

“I don’t like physics. It has a few topics which are very difficult and I couldn’t understand, like relativity theory, it is impossible to understand such a topic. I like biology and chemistry especially: oxidation and reduction reactions.”

"I really like chemistry because new and energetic ideas emerge. It provides us knowledge about drug synthesis, and their effects on our bodies. My previous teacher was providing us with tricky exam questions and that was very useful for me. But, I don't like math and English."

"I like chemistry especially the world of molecules, their speed during their interaction."

"I like chemistry, it is very interesting especially the reaction of sodium chloride and the nature of materials, I also like mathematics especially the topic of equation and in-equation."

"I like physics science especially the topic of free fall."

"I am affected by the personality of my uncle who is a scientist and living outside Syria. Science is more interesting than any other things due to its applicability."

"I love biology due to great ability to apply its ideas. Moreover, I feel relax whenever I study this course."

"I like biology especially the world of animals and chemistry especially chemical reaction; I feel that when the teacher likes his subject, we will also like it."

When students were asked about the relevance of science in daily life, the majority of the answers were affirmative. 10 students out of 26 were able to give examples applicable to daily life.

Exemplary quotes from students about the perceived relevance or science:

"In chemistry we can apply energy concepts in our life. Energy and power are mostly used everywhere. In biology, we study human body and understand the functions of every part. In physics, when we focus on distances and speeds we use, then we are able to calculate required time to reach goaled places."

"When we play football, we can apply physical laws comparing between free falling of body and providing it with initial speed."

Students were also asked whether they engage in science related-activities outside of school. The answers varied in this respect. Some students mentioned using the Internet, Facebook and YouTube for finding educational pages and instructional videos to increase their knowledge in science, while others mentioned watching corresponding television formats, e.g., The National Geographic Channel to learn about wildlife. The Syrian Educational Channel is also popular among the students. Some of the students even use online translation tools to translate information to Arabic when information is only available in English. Some other students opted for reading books. Another student expressed interest in watching movies based on science fiction and learning further about science from their friends. Some students affirmed their own desire of not engaging in such activities outside of school. Practical scientific activities are mostly absent outside school. However, when students are on a family trip to their village, there is often the possibility of engaging in planting and other farming activities. Also students suggested utilizing the workplaces of their parents if they work in the field of science. 22 of 26 students performed any practical activity – if possible - at home. 4 out of 26 students outside their premises, 2 in planting and 2 at their parents' place of work.

Exemplary quotes from students about using non-formal educational science resources in their leisure time:

"I like to do activity outside home in the field of agriculture. I am planting jasmine, apricot, roses, and other types of flowers. And I am interested in simple physical and chemical shows [such] as the reaction of lemon and marble."

"I like to search for scientists' biographies via the Internet."

"I like watching the National geography channel."

"I like mountain tourism and camping."

"I don't do any scientific activity outside school. I should take another type of life and live free of seriousness."

Students were also asked about their parents' attitudes towards their achievement in science. Most answers affirmed that parents exhibit a highly positive attitude towards their children when they achieve high scores in these subjects. 16 out of 26 mentioned that their parents care more about how their children score in science than in many other subjects. However, there were also other parents looking instead for high achievement in math or foreign languages. 2 of the 26 participants' parents cared more about gaining knowledge than good marks, the other replies were unclear or not specific to science.

Exemplary quotes from students about their parents' appreciation of science learning achievements:

"My parents are very proud among the people when I achieve high grade in scientific courses, because it is considered good indicator to get high level chances for a prestigious job in the future."

"My parents are more interested in knowledge more than scores"

"My parents become very happy when I am highly scored in mathematics and English."

Overall, as far as preferences for the different branches of science are concerned, physics and chemistry were viewed as the most applicable to everyday life, with examples such as the rusting of metals and the laws of motion in physics in sports and driving etc., although the topics mentioned in relation to biology were nearer to everyday life and the human body. A variety of fields were mentioned in chemistry, like industrial chemistry, chemical and environmental engineering, as well as a strong component of pharmacology and clinical medicine in chemistry lessons. It was also suggested that it was useful to learn about the negative effects of chemistry, e.g. releasing toxic fumes and gases in the environment, although this might contribute to a negative perception of the subject and may contribute to a decline in continuing the learning of chemistry (Breuer, 2002). Biology lessons were described as less motivating, due to the high load of memorization required while studying biology. But, in the same time it was described as interesting because of the relevance of processes in a human body, for example the working of the respiratory system.

Most parents evaluate their children based on high rankings which are obtained in science subjects - as well as in mathematics or English - since they consider them as an indicator for a potential career in the medical or engineering fields where prestigious social status is the key player in future highly paid jobs (Schalock, 1998). Parental beliefs about science can have a positive impact on the children's interest and self-efficacy in science. Research has shown that an enthusiastic attitude of parents towards science can consequently generate positive attitudes of their children towards science and can lead to developing a real interest in that field (George & Kaplan, 1998).

Science careers

The third section of the interviews dealt with students' expectations towards a potential future in the field of science and engineering. The participants were asked about their career plans and intentions and were inquired about the reasoning behind them. 10 out of 26 students would prefer to study medicine; and another 11 out of 26 could think to embark in engineering and technology studies. One student had a relatively contemporary view and wants to work in the field of sustainable energy. The others are distributed on other types of professions. However, career choices among many of the students were unclear and might not be finally reflected yet. It seems that there is a lack of identifying students' talents and giving them a clear career orientation by the science curriculum.

Exemplary quotes from students about their potential career choices:

"I like medicine. I am full of curiosity about how surgeon operation is being performed."

"I like to be digestive doctor since I appreciate decreasing the suffer from stomach pain."

"I like the dentist faculty or pharmacy because the way to reach the exam is not too long."

"Since I have strong English language so I think my possibilities align with pharmacy faculty, so it is very easy to memorize the drugs' names."

"I like to study one of the following faculties, pharmacy because I like medicines structures and how it enters the body and perform in specific organs, or music faculty, or French literature."

"I am curios to investigate discoveries and I like the faculty of scientific research, or techno-communication engineering."

"I like to be a vet since I like animals, or informatics engineering due to my great interest in languages of programming."

"I like the cars world and I would like to be sponsors for sporty racing. But, I am confused because all my brothers and sisters are doctors. So pharmacy may come in the middle way between what I would like to be and what I should be, because it doesn't need such long period to finish and in the same time, it is considered as a prestigious career. Or I may study informatics engineering or economy."

"I like to study economy faculty, or civil engineering or petroleum engineering."

"I like agriculture engineering because my father is working in this field and if it doesn't work"

"I like any faculty in regard of engineering and languages."

Students opting for medicine did so mainly because this profession allows them to work in public service while in the same time getting a high social status in the society. One student said that her desire for studying medicine is due to curiosity while another saw dentistry as an easy career option. In case, students' inclination towards pharmacy was explained by their interest in chemistry

– but also language in one case. A large group of students showed interest in opting for engineering as a future career, ranging from technical to agricultural engineering. Some considered it as a more financially rewarding career, while others had family members that had influenced their interest. Only a hand full of students focused in the direction of economics, but many of the students interested in science and engineering also were considering careers outside the field of science, like literature, music etc.

In many cases it seems that students do not select their future career according to their intrinsic motivation or according to prior knowledge of the nature of these careers. Most of the time, the reason for choosing a specialization seems to be caused by its social and financially rewarding prospects, while in some cases students are influenced by the guidance and advice of parents without taking into account their talents, abilities and attitudes, or may venture into a particular specialization just because of knowing someone who has succeeded in the field but ignoring that they might have different individual capabilities.

Table 2 summarizes the results from the whole study.

Table 2. Overview on the findings

<table>
<tr><th>Core category</th><th>Sub categories</th><th colspan="4">Students number</th></tr>
<tr><td rowspan="10">Science lesson</td><td>Daily life as an introduction</td><td colspan="4">5</td></tr>
<tr><td rowspan="2">Facilities</td><td colspan="2">Lab</td><td colspan="2">ICT</td></tr>
<tr><td colspan="2">14</td><td colspan="2">6</td></tr>
<tr><td>Activity to reinforce science</td><td colspan="4">8</td></tr>
<tr><td>Student-student interaction outside class only</td><td colspan="4">16</td></tr>
<tr><td>Dominant textbook usage</td><td colspan="4">17</td></tr>
<tr><td rowspan="2">Problems</td><td>curriculum</td><td colspan="3">pedagogy</td></tr>
<tr><td>13</td><td colspan="3">4</td></tr>
<tr><td rowspan="2">Non formal aid</td><td>Family</td><td colspan="2">Tutorial</td><td>Private Institute</td></tr>
<tr><td>13</td><td colspan="2">1</td><td>1</td></tr>
</table>

	Recent changes	Circumstances at a time of crisis		Curriculum	
		5		8	
Favourite sides of science and motivation	Interest in science	14			
	Most interesting field	Chemistry	Physics	Math	Biology
		9	3	1	1
	Science within daily life	10			
	Science within leisure time out of school	Home		Outside home	
		22		4	
	Parents' view on science achievement	Formal achievement		Knowledge	
		16		2	
Science career	Favourite future career	Medicine	Engineer	Renewable power	Other
		11	10	1	5

Conclusions and implications

In this study, questions were investigated focusing on the students' perception of their science lessons, beliefs about science, interest and motivation to study science, their parents' attitude and acuity, as well as learning science as a subject and thoughts about developing a science-based career in their future lives, and, finally the impact or role played by the acquired science knowledge in course of their daily lives. To accomplish this, 26 Syrian secondary school students were selected and interviewed for this study.

With regards to the students' perception about their science lessons, it was observed from their responses that the teachers mostly prefer to teach in a quiet atmosphere with little or no disturbances from the students. Teachers sometimes even discourage the students from asking questions during the lessons and force them to only ask questions for clarification about points that are not clear at the end of the lessons. It is like a regimented system (Hajji, 1994) meaning the participation and contributions of the students are not taken into consideration most of the time when teaching.

Furthermore, it was evident that most teachers' modes of teaching do not encourage general class discussions among the students, which are supposed to breed the good interaction, effective reasoning, and communicative skill and argumentation (Newton & Osborne, 2000) needed to understand the topic of the lesson being discussed by the teacher. Thus, the students are seriously affected by not gaining a proper understanding of the curriculum and by an approach that mostly compelled the students to resort to self-help from textbooks and relatives for understanding of the theoretical principles and practical applications of what is being taught by the teachers. Hence, some of the students need to rely on extramural training and classes or relatives after school hours to catch-up with areas of the lessons that are not too clear to them when discussed by the teacher during class (BouJaoude, et al., 2009).

Students' interest and motivation are key factors to improve understanding of science-related subjects. The findings from this study clearly indicate that most of the students do genuinely have some interest in studying science. Unfortunately, their teachers strictly control modes of teaching and do not motivate the students for actively grasping the essence and relevance of science as applicable to their daily life and future (Bevins, Brodie & Brodie, 2005). Moreover, the few of the students with a keen interest lack the required support and practice when compared to their colleagues in the western world that are well exposed to practical work, modern ICT, and contextualized knowledge (Kim, Hannafin & Bryan, 2007).

Concerning career interests, it was observed that many of the students from this sample are generally interested in careers in science, medicine and engineering, but most of them are not very clear in their choice yet. It also seems that not all are given the free-will and opportunities to think and decide on the right future career based on their intrinsic aptitude and genuine interest in disciplines that could promote their level of intelligence and the motivation in following through any chosen career path (Vetleseter & Henriksen, 2013). This clearly shows that the Syrian government urgently needs to incorporate guidance and counseling courses in the school educational curriculum to create a forum for the students to express their interest willingly, and for them to be properly guided onto career paths that would lead them to achieving success in the future, which may not necessarily be science for some of the students (Amoah, Kwofie & Kwofie, 2015).

It is quite important for Syria and most of the Arab countries that are affected by these serious educational challenges to work towards recruiting more qualified science teachers with sound academic backgrounds, experienced laboratory practice with excellent international exposure to contemporary issues in the field of science, in order to guide students towards career orientation and proper preparation for further training (Lederman, 2009). It would also be recommended that the Syrian teachers should be exposed periodically to high-quality continuous professional development seminars and conferences in education which can enhance their teaching abilities and capacities to impact the ideal scientific knowledge in teaching science subjects to secondary school students. This, in general, would raise potential for students' understanding and might promote their genuine interest in learning and applying science knowledge in their day-to-day activities (Elliott et al., 2008).

Chapter 5: Summary and Implication

Summary and Implication

This dissertation intended to analyze the nature of the science teaching in Syria with a special emphasis on chemistry education (Chapter 1). It was operated through a triangle-based study of the intended curriculum, teachers' and students' views. The 10th grade Syrian intended chemistry curriculum has been analyzed as a case based on an analysis of the official grade-10 chemistry school textbook in comparison to six other chemistry textbooks from a purposeful sample of Arab countries, namely Algeria, Egypt, Kuwait, Palestine, Jordan and Saudi-Arabia. These countries are economically, societally, cultural and geographically diverse, but they all are part of the Arab world and use Arabic as a common language (Chapter 2). The second part of this study analyzed teachers' views on chemistry and physics teaching based on interviews. Instances of the interviews were the use of ICT, laboratory work, including the history of science in teaching, and the teachers' view on the national curriculum (Chapter 3). In a third step, grade-10 science students' attitudes and views towards science education were surveyed by interviews with respect to their possibilities for participation in the science classroom, practical work, out-of-school science education, and their current views on potential careers in science and technology (Chapter 4).

School science textbooks are very important learning tools and indispensable, since they are representing the subject towards the learner (Deverak et al., 2013). Textbooks are a chance to connect the school science subjects to daily life and societal contexts. They offer chance to suggest practical activities to make science learning more comprehensible and meaningful to the students (Butler, 2009). According to the study described in Chapter 2 (see also Khaddoor et al., 2017), it was observed that the nature of the intended curriculum in Syria is mainly dominated by theoretical knowledge. However, there are indications towards slightly more modern views on the curriculum by operating contextualization, student-orientation to some extent (Muhanna, 2011) and the inclusion of modern topics from chemistry, as, e.g., suggested in Eilks, Rauch Ralle and Hofstein (2011). Here the Syrian intended curriculum can be considered to be among the slightly more modern approaches when compared to countries like Algeria, Kuwait, Jordan or Palestine, although the textbooks from Egypt and Saudi-Arabia intend to promote even more contextualization and student-orientation (see Chapter 2).

It seems that the new curriculum represented by the current textbook intends to innovate chemistry education in Syria by more illustrations, talks and a more appealing representation of the chemistry content (see Chapter 3). However, it is also clear that the new textbook in Syria must be considered as a first approach to modernizing the intended curriculum. The analysis in Chapter 2 shows that in the cases of Egypt and Saudi-Arabia more contemporary approaches of textbooks in Arab countries exist compared to Syria with regards to the degree of contextualization, social impact, daily life views, and situated learning theory (Greeno, 1998). This shows that the Syrian chemistry textbooks are still quite far away from what is internationally considered to be a modern textbook.

The analyzed textbook from Syria currently lacks in foci on modern topics involving science, technology, but gives at least some reference to environmental issues. Several issues are represented as was typical many years ago in Western countries. This is a cause for concern and needs to be critically examined to know the reasons why, in the twenty-first century such textbooks are still issued in Syria, or (with an even more traditional character) in Algeria, Kuwait and Palestine. From a theoretical point of view, the question must be asked why education authorities and textbook authors suggest that this traditional approach is still to be operated, and why modern educational theories, e.g. situated cognition (Greeno, 1998), studies on students interest (Sjöberg & Schreiner, 2006), or models for the relevance of science education (Stuckey et al., 2013) and related theories, are not taken into account when developing new science textbooks in many countries. This leads to the situation that parents' and students' views are often not considered when drafting the school curriculum (Mansour, 2010). It can be suggested that the schoolbook authors are more driven by a desire to maintain traditional notions about the classroom than developing a curriculum based on modern educational theory and evidence, hence students' personal orientations or experiences are neglected and thus the scientific knowledge acquired has little or no effect on their daily way of life and personal development. In view of the above, it is suggested that another round of educational reform is needed, taking the views of different stakeholders on the curriculum into account (Tiwari, Chan & Law, 2002). It is suggested that any proposed Arab chemistry textbook in general, and also Syrian chemistry textbooks in particular, should focus more on contemporary topics, follow students interests, focus relevant science, and use analogies, practical work and ICT more thoroughly to serve the local needs of a modern society today (Mansour et al., 2014).

Also the history and philosophy of science might be respected more thoroughly (McComas, 1998) for encouraging students and explaining to them what science is about, how sicince emerged and is operated, and what potential careers in them there might (Khaddoor et al., 2017). A complete absence of the history and philosophy of science – as is mainly the case in all the Arab textbooks - eventually leads to students and teachers developing an erroneous picture of what science is and eventually considering it as irrelevant and unnecessary in the scope of their knowledge development as individuals, and for science in society, as it is suggested by educational scholars in the west (Goodlad & Su, 1992). Textbooks should also respect more local and national cultural references and contexts to be up to date and well-structured to cater citizens for the 21st century in a given culture (Oblinger, James & Oblinger, 2005).

Overall, it could be stated that the current intended Syrian chemistry curriculum, from the way it is designed, starts to connect chemistry better than before with life, society and other subjects, such as Biology, Physics, Mathematics, Arabic and Latin language. These connections intend to form a better and more coherent understanding of chemistry with relation to other relevant domains. Also, the curriculum has started some first attempts to explain chemistry in relation to environmental issues such as air and seawater pollution, global warming, the danger of plastic product usage and other important topics that could raise the students' awareness about their surroundings and attract their attention to studying chemistry in response to the recent changes in the global environment as it has been suggested by Ambusaidi and Al-Shuaili for improving science education in the Sultanate of Oman (BouJaoude et al., 2009). Nevertheless, we face many more challenges to make the curriculum even more up-to-date and networked with the interests of students and society. However, there is hardly any information available as yet as to how this new curriculum is perceived and operated by the teachers and their students – and how an even a more revised version might be.

The studies in Chapters 3 and 4 try to give some insight into how the new intended curriculum is perceived by teachers and students and how teaching in the sciences with a special emphasis on chemistry teaching is operated. Though the Syrian teachers and students were more satisfied with the improved visual representations offered in the new curriculum, when compared to the old one, more than half of the teachers from the sample in Chapter 3 were still not satisfied with the new curriculum. The curriculum, as represented by the textbook, is still considered to be too theoretical in focus and overloaded with theoretical knowledge. The teachers complain that this intended curriculum is incompatible with the students' intellectual abilities and the specified time available for teaching this content in class to their students. This is in line with Abd-El-Khalick (2003) who observed that teachers regularly need to add more supportive context in teaching students good and strong scientific content, but the teachers are generally complaining about the bulky curriculum which leads to deficiences in driving theoretical knowledge towards reality (Abd-El-Khalick, BouJaoude, Duschl, Lederman, Mamlok-Naaman, Hofstein, Niaz, Treagust & Tuan, 2004). Also many students often do not feel able to cope with the curriculum. They complain about both the curriculum and how it is operated by the teachers (Chapter 4). Hence, many students try to cope and understand the curriculum with help of their relatives and friends and in rare cases to tutorials which have become something like a chronic disease in recent times (BouJaoude et al., 2009).

It is often the case that the students complain more about the limited and teacher-centred pedagogy and a lack of inter-student communication, demonstrations and illustrations, than the intended curriculum as such. It seems that in Syrian chemistry classes less than half of the teachers make use of laboratories. There are students that typically visit the laboratory only a few times in their lifetime as a science student and sometimes they never have the opportunity to do so. In contrast, it seems that a growing number of teachers have positive views on including ICT in their teaching more thoroughly to enrich the pedagogy and the operated curriculum. However, teachers also complain about a lack of infrastructure and growing problems with it in times of civil war (Chapter 3). For future studies, it would be pertinent to carry out an extensive research, beyond science education, on the effects and implications of the current Syrian crisis on the educational system holistically, by considering the new circumstances and events resulting from the socio-cultural issues with destroyed infrastructure and national instability (UNICEF, 2016).

The study of the students' view of the operated curriculum and pedagogy suggests that most teaching and learning in the physical sciences is dominated by the teacher. Teachers form the centre of any classroom activities and a passive role for the students is dominant in science classrooms, according to the views of the 26 students of the Syrian secondary school interviewed in this study (Chapter 4). The teacher plays the key role in the classroom and activities are mostly teacher-centered, as e.g. characterized in the case for Jordan by Al-Amoush et al. (2011). A situation whereby the teachers are active and the students remain passive is not suggested to be effective for good learning (Eilks et al., 2013). There is a significant interest among some of the students from this sample to get actively involved in activities relating to science. However, this interest is neither fulfilled by the curriculum being used nor the pedagogy applied by the teacher. Students escape to other means of learning outside the school by watching educational channels on television or following social media and websites with corresponding contents needed for proper understanding. Practical activities in the classroom are also suggested to be negatively affected due to the lack of proper infrastructure caused by the ongoing civil war in Syria. So, currently the culture of productive leisure time is mainly achieved at home unaffected by the gender factor which has a quite large effect on a society such as Saudi Arabia (Al-Sobayel, Al-Hazzaa, Abahussain, Qahwaji & Musaiger, 2015). Besides, it is very evident from the data gathered from this study that many Syrian students are highly interested in chemistry-related topics. Parents are proud of their childrens' achievements in science resulting from the newly enhanced curriculum. Furthermore, it has been observed that Syrian students are inclined towards studying medical and engineering subjects for a good professional career and future opportunities due to their societal status and the post-school opportunities which tend to be very rigid with regard to entering medicine and engineering faculties according to a UNDP investigation in many of Arab states (Sultana & Watts, 2008; UNDP/ RBAS, 2003). However, decisions about future career options seem to be mainly based on the financial and social stability of the profession instead of the nature of and interest in the profession itself. Such a phenomenon can be found everywhere but it is more prominent in underdeveloped countries that are in a constant state of instability and anxiety of undesired changes that could occur in the future (Zaleski, 1996), as is the case in Syria today.

Based on the interviews conducted with secondary students (Chapter 3), students' performance and attitude from their perspective are mainly influenced by the teachers' teaching style and the textbooks used. Other indirect factors that affect students' attitude are the connection between the scientific subject matter, their daily life, and the practical application of the learned scientific knowledge – issues that are mainly absent in current Syrian classes. It was observed that students in the secondary school stages prefer practical activities for good motivation, which is the case in all of the applied sciences accordingly (Palmer, 2007). Regrettably, activities such as laboratory experiments, group activities, or internet researches are rarely adopted in science teaching in Syria. It was very obvious that the students that attend lessons with good and applicable examples and activities, such as supporting teaching aids like illustrations, scientific videos and interesting questions, show better attitude and improved motivation in the classrooms. This was more the case for teachers teaching in private schools, than for those teaching in public schools only.

It is also apparent that the Syrian science curriculum needs to be constantly revised, for it to be in line with the current trends of modern day science and technology education. The incorporation of contemporary and relevant topics is crucial towards ensuring that the teachers are up to date with their European and American counterparts. This will promote better understanding of the curriculum by the teachers and also provide them with enhanced methods of impacting the objectives of the related topics when teaching the students, as it has been described in previous educational research in Arab world (Badran, 1993), and also the students if they still choose to use the curriculum independently. However, the reasons why contemporary and controversial topical areas like the chemistry of genetic engineering, green chemistry, renewable energies or alternative materials are largely neglected in the science curriculum and almost non-existent in the classroom environment, in spite of plenty educational researches declaring that they are very motivating and promising for students (Stolz et al., 2013), need also to be further researched.

Students' attitudes and opinions towards science are also gravely affected by cultural and social factors, especially when the science concept is associated with future careers. Many students see science at the junction of positive angles as a pathway to the financially lucrative fields of study of medicine and engineering, meaning that their impressions and opinions at this stage are completely different from a purely scientific focus. Hence, it is suggested that cultural and professional contexts are to be used more thoroughly to re-orientate the curriculum and its related teaching practices to make science more relevant to the students as described in previous studies (Stuckey et al., 2011).

A more student-active teaching and learning methodology should be achieved by considering students' active participation and contribution as a key tool in the science classroom learning environment. This has the potential to reduce the level of misconceptions and mismatches in the student-curriculum and student-teacher relationships, and to facilitate effective delivery of science concepts with minimum efforts during teaching (Oliver-Hoyo, 2011). Classroom activities may appear to divide the class students into different groups based on world link technique (Oakley, Felder, Brent & Elhajj, 2004) but open discussions could be used and adapted among students from outside into the classrooms to help students better make sense of science and learn how to debate about it. It is suggested that teachers should use more open discussions among the students to also enhance their ability in better decision-making and problem solving processes. This method has been shown to be far more effective than the lecture-based approach prevalent across the Arab world (Faour, 2012).

It is highly recommended to engage students in practical and communicative group activities in order to spread the mentality of sharing and active participation (Anderson, Mitchell & Osgood, 2005; Eilks et al., 2013), but these methods are not very common in Syrian schools – especially in times of the civil war. The civil war in Syria has badly affected – and still does affect - any intended and anticipated improvement in the practice of science education due to lack of electricity, poor teaching methodology, ruined infrastructures, overcrowded classrooms, a huge internally-displaced population, immigration and an unstable political situation, not to mention a delicate social environment (Chapter 3). Some of the interviewed students mentioned that the crisis had also affected them psychologically (Chapter 4). Thus, the resulting negative effects are gradually preventing them from concentrating on their studies and indirectly limit their ability to be creative or develop intellectually. However, the students and teacher relationships in Syrian culture with regards to active participation in science learning, effective contributions on specific practices and teachers' and students' on current scientific knowledge should be further investigated to inform the necessary reforms.

The issue of practical applications is essential in instructing students for better motivation and performance enhancement (Schiefele, 1991). It is very disappointing to note that most of the interviewed students have never been to the school laboratories and do not have the opportunity to actively participate in experiments in the classroom for better learning and understanding. While some of them stated that they usually have some experimental procedures in the classrooms as demonstrations instead of the laboratory, like burning of lead metal and some explosive reactions such as production of sodium hydroxide, others have never had such experiences. In a similar study teachers complained that the school context, parents, and students are against applying student-oriented pedagogies in chemistry classes (Al-Amoush el al., 2012). It seems that especially at this point there is a gap in the public educational sector.

The Syrian Ministry of Education needs to effectively and efficiently re-equip the schools with more robust, modern and attractive information, communication and technology materials and equipment in classes and laboratories to facilitate the teachers' teaching methodology, and as well encourage the students to see the school as a true citadel of learning, a place to build up a foundation for a good career and accept unconditionally the scientific principles as applied to the different science subjects being taught, similarly to what has been suggested in previous research (Dori, Rodrigues & Schanze, 2013). Generally, the educational system in Syria needs to be reformed. This can only be achieved if the Syrian Government is able to diligently look into the suggestions and recommendations highlighted above or in previous research with similar criteria all over the world in general and on Arab countries in particular, towards improving the domain of science teaching and modify the curriculum accordingly (Abd-El-Khalik et al., 2004). It is necessary to bring science classes and laboratories up to the twenty-first century world standard, thereby encouraging and motivating the students that are genuinely interested in science to learn and apply science knowledge, starting from an early age.

In view of all the described challenges, it would also be pertinent to consider continuous reform efforts in the intended curriculum and pedagogy to be accompanied by long-term continuous professional development (CPD) of teachers (Hugerat, Mamlok-Naaman, Eilks & Hofstein, 2015). This needs to focus on how to operate and develop a modern curriculum (Eilks et al., 2013) with modern and student-oriented pedagogies, as e.g. described in Eilks, Prins and Lazarowitz (2013). There is urgent need to invest in overcoming instructional inefficiency which over the years resulted from little or no training in pedagogy, didactics and psychology of learning. The situation needs to change to implement more professionalism among the teachers who seem to be more guided by traditions and personal beliefs than education theory, so that their beliefs act as filters through which all relevant learning and information on operating the curriculum is influenced; this is in line with with what has been mentioned by Nisbett & Ross, 1980. Any related approach has to take into account the teachers' views and attitudes within educational processes that should be regularly monitored and assessed to mitigate the observed challenges towards reducing hesitation before a contemporary pedagogical style (Loucks-Horsley, Hewson, Love & Stiles, 1998). Generally, it has to incorporate the four main domains of teacher interconnected professional growth (Clarke & Hollingsworth, 2002), namely the personal domain (beliefs, attitudes and prior experience), the practical domain (the authentic teaching practices of the teachers), the external domain (topics, requirements, media and curriculum) and the domain of consequences (goals and effects). How to operate this in the context of science education in Syria needs to be subject to further research, curriculum development and developing corresponding teacher continuous professional development. Corresponding models are available that might be adopted to the Syrian educational context (Loucks-Horsley et al., 1998, Mamlok-Naaman & Eilks, 2012).

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